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# Improving Educational Research Allocation in Maine

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**Executive Summary**

Few issues in Maine generate more passionate debate than the issue of consolidation of public education resources. Moreover, this debate has become increasingly prominent in recent years as state and local budgets have tightened, and the school-age population in many areas has decreased. Unfortunately, there is little objective evidence to inform this important debate. The national research on school and district size is not pertinent to the debate because the vast majority of Maine's school districts have far fewer students than the national average. Maine's decision makers need relevant and reliable information to inform their difficult choices.

This study attempts to fill this information gap by quantifying the relationship between education costs and school district size (as measured by the number students). This report also quantifies the relationship between educational outcomes and school district size. The data examined in this study are at the school district level. Hence, the results are relevant to discussions of consolidating school districts within Maine. The results do not directly apply to discussions of consolidating individual schools.

The data indicate that:

- If socio-economic factors are taken into account, there is essentially no relationship between school district size and educational outcomes in Maine. Over the range of school district sizes that exist in Maine (all but one have less than 350 students per grade); the size of the district does not have an appreciable effect on measurable educational quality.

- There are huge potential cost savings from greater consolidation of Maine's public education resources. Many of Maine's school districts are too small to achieve cost efficiency. There is unnecessary duplication of educational infrastructure in Maine's public education system, particularly in school district administration.

Together these findings show that there is considerable merit to the idea of greater consolidation of K-12 resources in Maine. As long as consolidations were geographically rational, considerable cost savings could be achieved, and educational quality would not be compromised. Indeed, at least some of the cost savings could be used to enhance the educations that we are providing to our children.

## I. Introduction

Demographic changes and budget deficits in Maine and other rural states are creating impetus for greater consolidation of public education resources. Forecasted trends for Maine indicate that already-small rural schools and school districts will become even smaller in the near future. Without significant restructuring, the fixed costs of providing educational services (administration, facilities, etc.) will be spread over fewer and fewer students, thus raising per-student costs. These rising costs have become difficult to ignore in light of several years of revenue declines at the state level and increased demand for state funding from local communities. Education is the largest expenditure item in state and local budgets nationwide; about four of every ten state and local tax dollars goes to K-12 schooling. Thus, efficient use of educational resources is clearly an important component of efforts to control costs and reduce tax burden.

Shortly after taking office in 2003 Governor John Baldacci announced plans to encourage cost savings through greater regionalization in the administration of Maine's public education. In 2005, the state legislature passed and the Governor signed a tax reform act that established funds to support communities striving to reduce costs through regional collaborative approaches. In-depth analysis to inform these efforts is limited, however.

In 2002, a group of 15 communities in Penobscot Valley asked the Margaret Chase Smith Policy Center for quantifiable information on the costs and benefits of regionalization. In general, the Center's exploratory investigation[1] found potential for significant cost savings from collaborative approaches to service delivery in the areas of education, housing, and capital planning.

These results attracted a great deal of interest throughout the state. Although it was the most in-depth analysis of the allocation of Maine's educational resources to date, it was not a sufficient guide for public decision making. Because of the project's limited budget and time frame, the research was limited in a number of important dimensions. This study addresses these shortcomings in several ways.

First, this study examines educational outcomes in more depth. In particular, the analysis of educational performance controls for socio-economic factors beyond the classroom that may affect student performance. These indicators include adult educational attainment within the community, property values, and median family incomes.

Second, this study measures school district size by the number of enrolled students rather than resident students. Resident and enrollment numbers are often very different because there is considerable tuitioning of students across school districts in Maine. School districts are typically evaluated using resident students, but student enrollment is the more appropriate measure of the scale of educational operations.

Third, this analysis controls for several factors that may create variation in school district costs, such as assessed property value per student, teacher qualifications, and teacher/student ratios.

Fourth, this study examines five years of data (1998-99 through 2002-03) rather than one year. This increases the reliability of the results by smoothing over year-to-year fluctuations.

Lastly, this analysis more carefully estimates the cost savings that would be realized if Maine's school districts were a more cost-effective size. It does this by

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[1] See Chapter II of Allen, Bell, and Trostel (2002) or Trostel (2003).

estimating a better-fitting form of the cost curve, by calculating the confidence intervals of these estimates, and by estimating the cost differentials on a case-by-case basis.

With the inclusion of these adjustments, our findings are similar to those in the initial examination. However, there are two important differences. One, the initial analysis indicated that there are substantial unrealized cost savings in Maine's K-12 system. The new findings suggest even larger potential savings. Two, the initial analysis indicated that educational outcomes were marginally better in Maine's larger schools. This study finds that the correlation is not due to the larger size per se, but to differences in socio-economic factors. When socio-economic differences are taken into account, there is little evidence of a systematic relationship between school district size and educational performance.

## II. Key Concepts

Public discussions of consolidation and regionalization can elicit strong feelings regarding community identify and local decision making. During these discussions, loaded terms can quickly make a debate emotional rather than rational. To some degree, differences of opinion on consolidation may be due to different understandings of key terms. For instance, some people interpret "consolidation" as closing schools and increasing class sizes while others mean combining the administrations of existing schools. One side is talking about apples, but the other side is hearing about oranges. Thus, a few important concepts deserve explicit discussion at the outset.

*Economies and Diseconomies of Scale*

The main concept behind the push for consolidation in public education is economies of scale – the principle that it is more cost efficient to make larger quantities rather than smaller. Cost per unit decreases as more units are produced when there are economies of scale. For example, if you want to make a dozen cookies, it is more efficient to bake one batch with twelve cookies rather than twelve batches of one cookie each. To some extent there are economies of scale in just about every activity. Whether we are talking about baking cookies or building airplanes, it is almost always cost effective to produce more than one unit.

Cost per unit declines when there are economies of scale because producing more units removes unnecessary duplication of effort. In the cookie example, baking one large batch of cookies rather than twelve small ones means that the mixing of the dough and the greasing of the baking sheet can be done once rather than twelve times. Another way of phrasing this is that the fixed costs of baking (the mixing and greasing) are spread over more units, thus reducing cost per unit.

Economies of scale are usually limited. At some point diseconomies of scale are encountered; production bottlenecks and supervisory problems become increasingly severe and cost per unit begins to rise as more units are produced. Going back to the cookie example, if one tried to make too many cookies at once the ingredients wouldn't fit in the mixing bowl, the cookies would stick together on the baking sheet, and so on.

Thus, cost-effectiveness is a balancing act. The ideal production level will be large enough to capture economies of scale, but no so large that diseconomies of scale are encountered. That is, one wants to be in the flat region on a U-shaped cost-per-unit curve like shown in Figure 1. This is true for baking cookies, building airplanes, and for organizing educational resources.

Economies and diseconomies of scale apply to productivity as well as costs. In fact, this is just another way of looking at it. For the reasons discussed above, productivity (output per unit of effort) increases up to a point and then decreases as diseconomies of scale are encountered. One wants to be in the flat region on a hump-shaped productivity curve like shown in Figure 2. Again, this is true in baking cookies, building airplanes, and for educating students.

In the case of education, the peak in the productivity curve and the valley of the per-student cost curve may not occur at the same scale of operations. Efficiency in educational performance and cost efficiency may occur at different school and school district sizes. Thus, there are likely to be tradeoffs among competing goals.

In the context of Maine's educational resources, the concepts of economies and diseconomies of scale lead to two crucial questions that can only be answered through close examination of the data.

- Where are Maine's school districts on the cost and performance curves? Consolidation proponents believe that Maine's public education resources are organized on a scale that is too small to reach efficiency in either performance or cost, or both. Consolidation opponents believe that increasing the scale of education would mean moving away from efficient levels.
- How much curvature is there in the cost and performance relationships to size? In other words, how much difference does it make if Maine's school districts are not operating at efficient levels? It may be the case that public education in Maine is

Figure 1
Relationship between Cost per Unit and the Number of Units

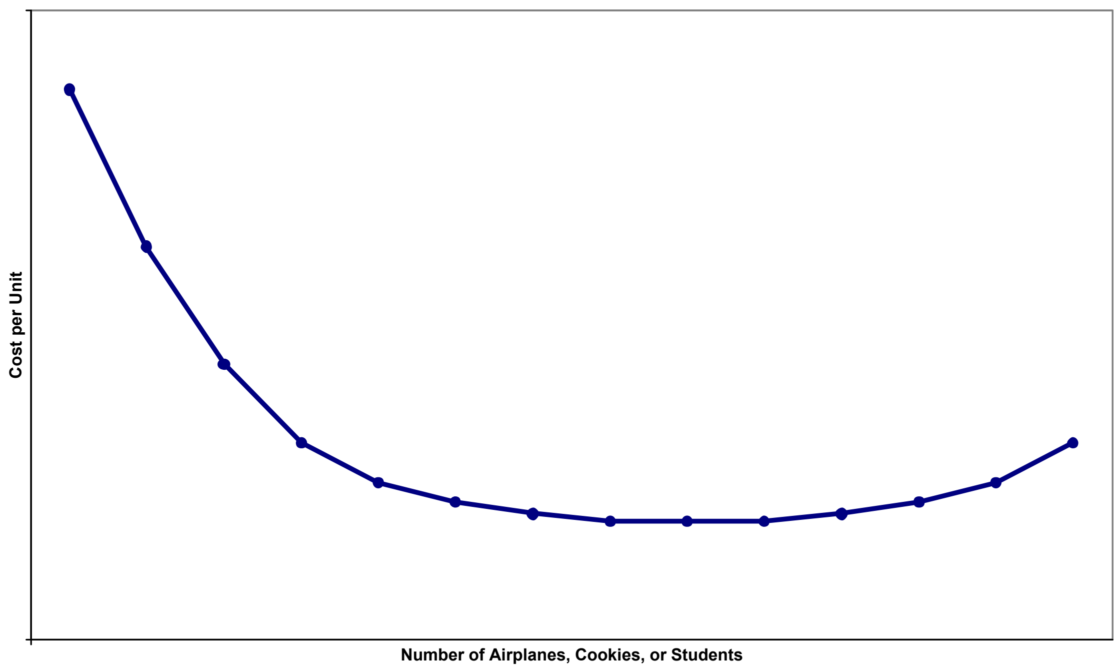
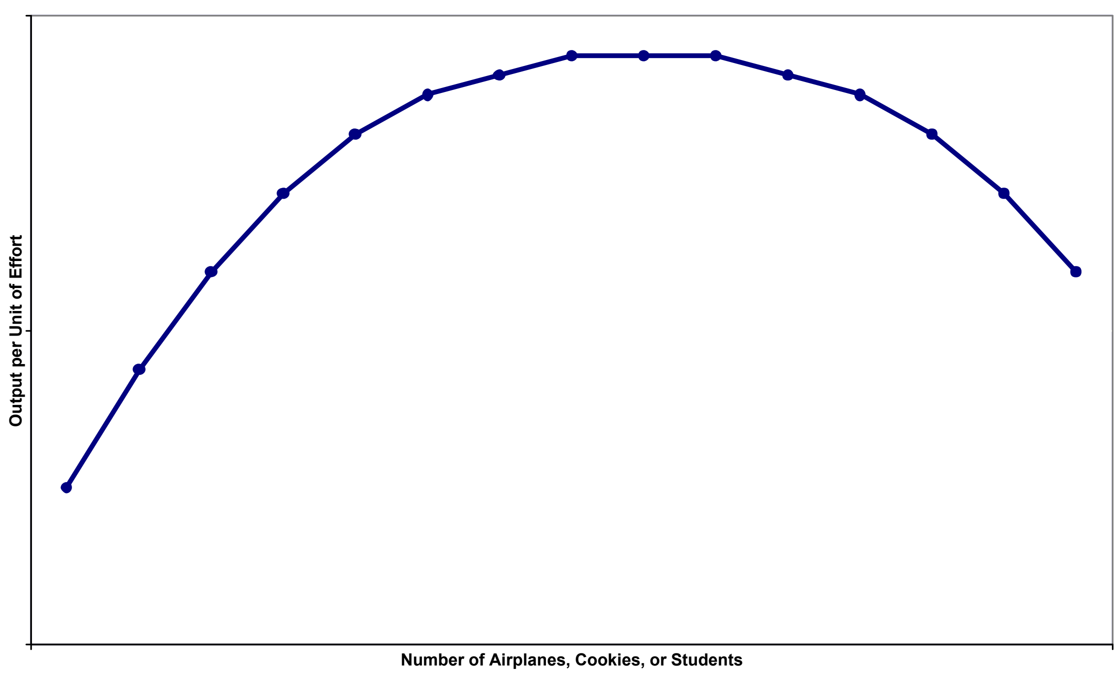



Figure 2
Relationship between Producitity and the Number of Units




organized on a scale that is less than efficient, but the potential cost savings or performance gains of moving to more efficient levels are negligible.

This study addresses these two empirical issues.

*Larger versus Smaller*

The worst abuse of language in the debate on school and school district size is in the use of the terms "larger" and "smaller". As suggested by the preceding graphs, neither larger nor smaller is necessarily better. What matters is how large or small a school district is compared to a reference point. Larger is certainly better when the reference point is one student per school, but is certainly worse when the reference point is 100,000 students per school. Without being specific about the scale of operations, arguments that larger or smaller is better are simply ideology, not objective debate. Despite this, the vague terms "large" and "small" are used freely, and not surprisingly inconsistently, in the consolidation debate. For example, school sizes that would be considered relatively "large" in Maine would be considered relatively "small" in New York City. To equate "smaller" Maine schools with "smaller" New York City schools is comparing apples to oranges.

Neither larger nor smaller is always better because the relationships between costs, educational performance, and size are nonlinear. That is, at a relatively small scale of operations cost per student and student performance are likely to improve as size increases, but at a relatively large scale of operations cost per student and student performance are likely to suffer as size increases. Thus, one cannot legitimately claim that educational outcomes or costs either improve or deteriorate with size without being specific about the scale of operations. These relationships are different at different sizes.

The nonlinear relationships illustrated in Figures 1 and 2 are the only types of relationships that make sense within the context of public education. The logical conclusion of a blanket statement such as "smaller is better" is that there should be one school per student. Clearly this is unrealistic. A blanket statement that "larger is better" (therefore, there should be one school for the whole state) is equally absurd. Whether smaller or larger is better depends on the reference point.

*Consolidation*

Consolidation can take many forms. To its opponents the term "consolidation" often evokes images of large, unmanageable classes and impersonal, monolithic schools. Consolidation could lead to such outcomes, but it does not have to. For example, consolidation could lead to larger average class sizes, but this might simply be the result of more full classes rather than larger classes per se. Similarly, consolidation could occur only at the administrative level and not necessarily in schools. That is, school districts could consolidate their administrations without necessarily closing any schools or creating longer bus rides for students. Indeed, Governor Baldacci explicitly proposed greater regionalization in educational administration without school closures. As with the terms "larger" and "smaller", the term "consolidation" needs to be put into proper context.

*School Districts*

Maine's public education system is administered by several types of "school administrative units". These include municipalities that operate their own school systems and groups of municipalities that join to form School Administrative Districts or Consolidated School Districts. Throughout this report, we refer to these school administrative units collectively as "school districts" or "districts".

All of the data examined in this study are at the school district level. Hence, the results are relevant to discussions of consolidating school districts within Maine. The results do not apply (at least not directly) to discussions of individual school consolidations.

## III. Educational Scale and Costs in Maine Relative to Other States[2]

Compared to the rest of country, most of Maine's schools are small. In 2000-01, the average school in Maine had 290 students. The national average was 506, almost 75% larger. Maine's number of students per school was 43rd among the 50 states.

Maine's school districts are even smaller in comparison to the rest of the nation. There were 734 students per school district in Maine in 2000-01. The national average was 3,177 students, 4.3 times larger. Maine's number of students per school district was 45th in the country.

Maine's schools and school districts will become even smaller in the near future unless there is some consolidation. According to the Maine State Department of Education, the number of primary and secondary students in Maine is forecasted to shrink by 12.5% between 2004-05 and 2013-14.

Maine's public education system is also somewhat costly in comparison to the rest of the country. Operating cost[3] per student in Maine was more than 11% higher than the national average in 2000-01. In terms of operating cost per student, Maine had the 11th most expensive public education system in the nation. This is despite Maine having an average teacher salary that is the 13th lowest in the country in 2000-01, more than 16%

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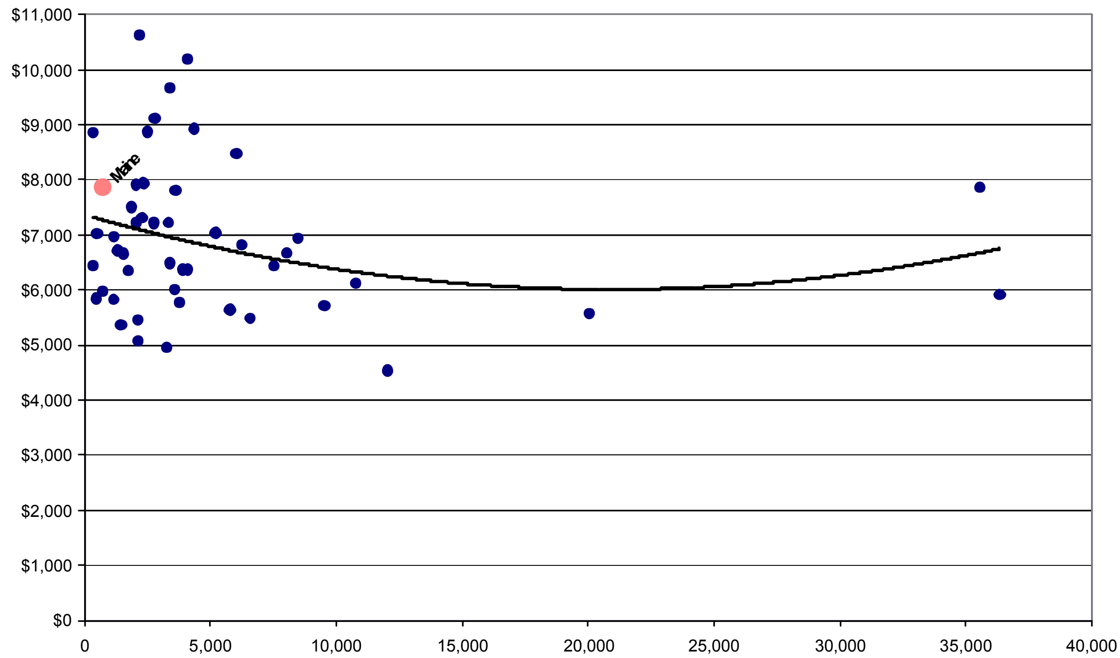
[2] All the numbers in this section were computed using data from the U.S. Department of Education, National Center for Education Statistics, *Digest of Education Statistics, 2003*.

below the national average.[4]

Figure 3 shows the average operating cost per student in each state plotted against its average number of students per school district.[5] Although there is a considerable amount of variation in the data, the curve of best fit indicates a U-shaped per-student cost curve. Maine appears to be on the declining portion of this relationship.

**Figure 3**
**Operating Cost per Student and Average District Size in Each State in 2000-01**




A few ratios suggest why public education costs more in Maine than in the rest of the nation. In 2000-01, Maine's public school systems had one full-time-equivalent employee per 6.2 students. This was the 2nd lowest ratio among the fifty states. The national average was one full-time employee per 8.3 students. Thus, Maine had 33% more employees per student than in the rest of the nation. Nationally in 2000-01 there

[3] "Operating cost" is total cost excluding capital outlay, interest on debt, and student transportation.
[4] At least part of this salary discrepancy is due to relatively fewer Maine teachers having advanced degrees. 31.9% of Maine public school teachers had advanced degrees in 1999-2000, compared to 47.4% nationally. Maine teachers, however, do have relatively more teaching experience than the rest of the country.

was one full-time-equivalent "school district officials and administrators" for every 816 students. In Maine there was one per 393 students. In other words, Maine had more than twice as many full-time school district officials per student than in the rest of country, the 6th highest ratio in the nation. In 2000-01, there was one full-time-equivalent "principals and assistant principals" for every 333 students nationally. In Maine there was one for every 230 students. Maine had 45% more school principals per student than the rest of country, the 4th highest ratio in the nation. These ratios suggest that Maine's small scale of operations in education creates more duplication in administration than in the rest of the country.

Maine's rural landscape is undoubtedly part of the reason for education being organized on a relatively small scale. It also undoubtedly is not the only reason. For example, Idaho, which has roughly the same population density as Franklin County, has the 5th lowest ratio of school employees per student (Maine has the 2nd highest), and New Jersey, which is roughly 3.5 times as densely populated as Cumberland County, has the 6th highest.[6] South Carolina has the 2nd highest number of students per school district administrator/official (Maine has the 6th lowest), and Ohio, twice as densely populated, has the 4th lowest. Population density is not the whole story.

## IV. Educational Scale and Costs within Maine[7]

The data presented in the preceding section are too highly aggregated to support strong inferences on economies of scale and possible cost savings from consolidation of

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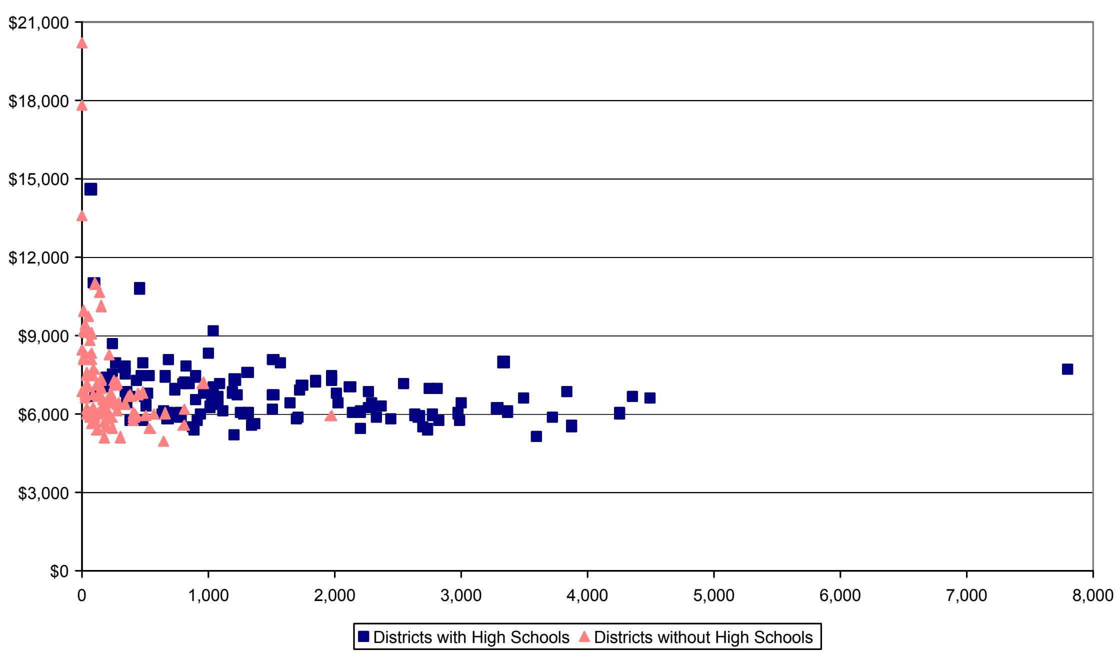
[5] Hawaii, with a single school district of 184,360 students, is omitted from Figure 3.
[6] U.S. Census Bureau, Population Density of Counties: July 1, 2003.
[7] Unless otherwise indicated, all the numbers in this and the following sections were computed using data from the Maine Department of Education.

Maine's public education resources. Since primary and secondary education is organized locally, it is more appropriate to examine data from individual school districts. Data of this sort are shown in Figure 4. For the five academic years from 1998-99 through 2002-03, this chart shows the annual average operating cost per student (adjusted for inflation) plotted against the average number of students enrolled in each of Maine's school districts.[8] Charts for each of the five academic years separately are practically identical to Figure 4.

**Figure 4**
**Operating Cost per Student and Number of Students Enrolled in each District in Maine**
**Average from 1998-99 through 2002-03, Adjusted for Inflation (in 2002-03 $)**




Because a large portion of Maine school districts do not operate secondary schools, and secondary education is considerably more expensive than primary education,

[8] Actually, Figure 4 only shows the 206 districts that operated schools and reported per student operating costs. The 60 districts that tuitioned all their students to schools in other districts (and therefore with no enrolled students) are not shown. Also not shown are 21 school administrative units that operated schools but whose costs were assigned to other units because of tuitioning students across districts. All 117 districts with secondary schools and 89 of the 110 districts with only primary schools are shown in the chart.

Figure 4 distinguishes districts with high schools ("HS districts") and districts without high schools ("NHS districts"). For comparable numbers of students, the NHS districts generally have lower costs per student. Those districts generally lie below and to the left of the HS districts. These NHS districts reduce costs by sending their secondary students to larger districts which can realize greater economies of scale. The HS districts are usually willing to accept students from other districts, even when the tuition rate is below their average cost per student (secondary tuition rates are capped at the state average cost per secondary student). A receiving district can still benefit despite a tuition rate below their average cost because the cost of the *additional* students may be significantly less than their overall average cost per student. That is, a receiving district can benefit from having more students share their fixed costs (administration, infrastructure, etc.) when the district is on the declining portion of the cost curve shown in Figure 1. Thus, both the sending and receiving districts can realize cost savings by moving from points on the downward-sloping part of the curve to a point on or nearer to the flat part of the curve.

Because of the way that the Maine State Department of Education reports the data, per-student costs are often compared to the number of resident students. Costs in Figure 4, however, are compared to the number of enrolled students, which is sometimes quite different because of tuitioning students across districts. The scale of operations, and hence cost per student, depends much more on enrolled students than resident students. Another way of thinking about this is that tuition rates are determined by the per-student operating costs where the students are enrolled (except in the instances where secondary tuition rates are capped), not where they reside. 60% of Maine's school districts tuition at least some of their students to other units; thus the distinction between resident students and enrolled students could be important.[9]

Although there is a considerable amount of variation in the data in Figure 4, there is a distinct U-shaped pattern between cost per student and the number of students, particularly when distinguishing between the NHS and HS districts.[10] The relationship between per-student cost and school district size is especially pronounced at the very low end of the scale, roughly below 500 students. Many of Maine's school districts are at this end of the scale. Of Maine's 227 districts that operated schools, 40 averaged less than 100 students enrolled, 31 had between 100 and 200 students enrolled, and 50 had between 200 and 500 students enrolled.

Of the 206 cases shown in Figure 4, the 5 school districts with the highest per-student operating cost all had with fewer than 100 students enrolled in their schools (all with fewer than 8 students enrolled per grade). The 12 highest-cost districts all had less than 465 enrolled students (each with fewer than 36 students per grade). The 24 highest-cost districts all had less than 1,050 students enrolled (each with 80 students per grade or less). Of the 24 highest-cost districts, 16 have less than 100 students and 6 have less than 465 students. Cost per student is also rather high at the upper end of the scale (for Maine). There appears to be at least one district on the upward sloping part of the cost curve. Portland, Maine's largest district with 7,304 students (600 per grade), had the 35$^{th}$ highest per student cost.

The pronounced negative relationship between per-student cost and school district size at very small sizes is not surprising. Cost per student is higher when the fixed costs

[9] Although exact numbers of tuitioned students are not available, it appears that about 6% of Maine students are tuitioned across school districts each year.

[10] Actually, operating a high school and district size explain almost 19% of the variation in per student cost shown in Figure 4, which is a surprisingly high proportion considering all the factors that can affect costs.

of operating schools are spread over fewer students. Consider the following. From 1998-99 through 2002-03, Maine had 65 districts operating schools with fewer than 55 enrolled students per school and school district administrator (recall that the national average in 2000-01 was 816 per administrator). Every one of these 65 districts averaged fewer than 230 students enrolled.

From 1998-99 through 2002-03, 35 school districts spent more than $1,240 annually (inflation adjusted) per enrolled student on school and school district administration. Of these highest-administrative-cost districts, 34 had fewer than 340 students and 24 had fewer than 100 students. The other district with relatively high administrative costs per student was the state's largest school district. Larger is not always better. Finally, there were 24 districts that spent more than $2,645 per enrolled student on administration and school operations (that means $2,645 or more per student not spent on instruction, nutrition, transportation, debt service, or new facilities). All 24 had fewer than 200 students, and 20 had fewer than 100 students. The 26th highest district in this cost category, though, was the state's largest school district with 7,800 students. Economies of scale only occur up to a point, and past that point diseconomies of scale can be encountered.

Apparently it is cheaper for some very small school districts to tuition all their students to other districts, but it is clearly more expensive than if these very small districts were simply merged into the districts where their students are enrolled. From 1998-99 through 2002-03, Maine had 60 school districts that did not operate schools and tuitioned all their X students to other districts. These 60 districts spent more than $850,000 annually (inflation adjusted) just on school district administration (which does not include transportation). This is equivalent to $378 annually per resident student not spent on instruction.

## V. Educational Scale and Quality in Maine

Educational experiences are multidimensional, and most of these dimensions are difficult or impossible to quantify. Thus, there is no way to precisely measure the quality of a student's education. However, there are a number of quality indicators that, when taken together, can reasonably measure the quality of educational services delivered by a school district.

Tables 1 and 2 summarize the relationship between various indicators of educational quality and district size in Maine during the five academic years from 1998-99 through 2002-03. These tables report the partial correlation coefficients between the indicators and the number of students enrolled per grade in Maine's school districts.[11] These tables also report the p-values corresponding to these correlation coefficients.[12] Given that there are compelling reasons to believe that the relationships could be different at different sizes, a quadratic (i.e., U-shaped or hump-shaped) specification is estimated along with a linear specification.

### Socio-Economic Variables

It is possible that an observed correlation between an indicator and school district size could be the by-product of both variables being correlated with something else which

[11] A correlation coefficient measures the strength of the relationship between two variables. A value of 1.0 indicates a perfect correlation; a value of -1.0 indicates a perfect inverse relationship; and a value of 0.0 indicates no relationship between the variables.

[12] A p-value is the probability that the coefficient is equal to zero. A p-value of 0.05 indicates that the coefficient is different from zero with a 95% degree of confidence. Values less than 0.10 or 0.05 are typically interpreted as indicating statistically significant correlations.

is the real cause of the effect on the indicator. For example, an observed positive correlation between performance and the number of students could be due to both being positively correlated with average income, rather than a real effect of district size. In other words, correlation is not necessarily causation. Thus, Tables 1 and 2 also report correlation coefficients after controlling for differences in average socio-economic characteristics across school districts.[13] These socio-economic variables are:

*Indian school districts* – Maine's three Indian school districts are likely to be different from other districts because of their distinctive ethnic composition. These districts also have much more federal government involvement than others.

*Percentage of enrolled students eligible for free and reduced school lunches* – This variable is the average over the four academic years from 1999-2000 through 2002-03 from the Maine Department of Education. It indicates the proportion of children whose family income is below 185% of federal poverty guidelines. We also performed trials runs using an alternative measure – the percentage of families with children in the district whose incomes were below the poverty line in 1999, available from the U.S. Census Bureau. However, the latter measure showed considerably weaker correlations with the outcomes in Tables 1 and 2.

*Percentage of 18-65 year old residents with an associates degree or higher* – This variable from the U.S. Census Bureau indicates the average parental education in the school district in 2000. It generally has stronger correlations with the outcomes in Tables 1 and 2 than other measures of average educational attainment (such as the percentage with a high school diploma, the proportion with a bachelor's degree, etc.).

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[13] Secondary schools are clearly different than elementary schools, but this is not a socio-economic characteristic. It, like student enrollment, is a school district characteristic. Hence, all the correlations

*Median income of families with children* – This variable is also from the U.S. Census Bureau. It indicates the average parental income in the school district in 1999.

*Percentage of single-parent families* – This variable from the U.S. Census Bureau indicates the extent of non-traditional families in the school district in 2000. Its correlations with the outcomes in Tables 1 and 2 are stronger than percentage of single-mother families.

*Number of residents per square mile* – This measure of population density from the 2000 U.S. Census Bureau indicates average student transportation times within each school district. We experimented with the number of residents per road mile (in 1997) from the Maine State Planning Office, and transportation cost per resident student (transportation costs are assigned to the district where the students are resident, not where they are enrolled). But their correlations with the outcomes in Tables 1 and 2 are usually somewhat weaker than the more typical measure of population density. The following results are very similar regardless of which measure is used.

**Teacher/Student Ratio**

Within each school district, the quality of instruction can generally be expected to improve as the ratio of teachers to students rises. It is also expected that the teacher/student ratio will fall as the number of students in the district increases. Even if maximum class sizes are unrelated to school district size, higher numbers of students will generally make more classes full, thus increasing the average class size and reducing the teacher/student ratio.

The correlation coefficients reported in Table 1 confirm that the ratio of teachers to students declines significantly as the number of students enrolled per grade rises. The

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(except for those pertaining only to high school or to specific grades) control for having a high school.

**Table 1**
**Correlations between Various Outcomes and School District Size**
**Averages in Maine from 1998-99 though 2002-03**

| | | Linear Specification | Nonlinear Specification | |
|---|---|---|---|---|
| **Outcome** | | **Enrollment** | **Enrollment** | **Enrollment$^2$** |
| Teacher/Student Ratio | | -0.2585 | -0.3730 | 0.2944 |
| | | *0.000* | *0.000* | *0.000* |
| Percentage of Teachers with Advanced Degrees | without S-E controls | 0.3012 | 0.2592 | -0.1366 |
| | | *0.000* | *0.000* | *0.041* |
| | with S-E controls* | 0.2564 | 0.2164 | -0.1111 |
| | | *0.000* | *0.001* | *0.100* |
| Attendance Rate | without S-E controls | 0.0725 | 0.1523 | -0.1343 |
| | | *0.278* | *0.022* | *0.044* |
| | with S-E controls** | -0.0895 | 0.0212 | -0.0671 |
| | | *0.210* | *0.768* | *0.349* |
| Dropout Rate | without S-E controls | 0.1844 | -0.1364 | 0.2368 |
| | | *0.046* | *0.142* | *0.010* |
| | with S-E controls** | 0.1426 | -0.0177 | 0.0949 |
| | | *0.139* | *0.856* | *0.329* |
| Percentage of Seniors Planning to Go to College | without S-E controls | 0.1652 | 0.1312 | -0.0667 |
| | | *0.074* | *0.159* | *0.475* |
| | with S-E controls** | -0.0410 | -0.0603 | 0.0467 |
| | | *0.672* | *0.535* | *0.632* |
| Home Schooling Percentage | without S-E controls | -0.1254 | -0.1356 | 0.0882 |
| | | *0.060* | *0.042* | *0.187* |
| | with S-E controls** | -0.0813 | -0.1182 | 0.0922 |
| | | *0.255* | *0.098* | *0.198* |
| Juvenile Arrest Rate | without S-E controls | 0.0405 | 0.0413 | -0.0263 |
| | | *0.655* | *0.650* | *0.773* |
| | with S-E controls*** | -0.1156 | 0.1523 | -0.2198 |
| | | *0.219* | *0.106* | *0.019* |

Notes:
P-values are reported in italics under the correlation coefficients.
All correlations control for not operating a high school (when applicable).
* These correlations control for the percentage of residents with advanced degrees.
** These correlations control for the percentage of residents with an associates degree or higher, median family income, population density, percentage of families with a single parent, percentage of students eligible for free and reduced school lunches, and Indian school districts.
*** In addition to the above, these correlations control for the adult arrest rate.

data also reveal substantial nonlinearity in this relationship. Indeed, practically all the correlation occurs in the range from 0 to about 50 students per grade. 79 districts had a teacher/student ratio of 0.096 or higher (i.e., less than 10.42 students per teacher), and all of them had fewer than 44 students enrolled per grade. Thus, Maine's very small school districts have higher teacher/student ratios.

Given that the teacher/student ratio is really a measure of an education input rather than an educational outcome, there is no reason to control for socio-economic variables (doing so makes very little difference anyway).

**Teacher Qualifications**

A rough measure of the quality of teaching is the percentage of teachers with advanced degrees. This measure is strongly correlated with school district size. Evidently, the larger school districts in Maine are able to use the cost savings from economies of scale to hire relatively more teachers with higher qualifications, which is consistent with the findings first shown by Riew (1966). Also consistent with the theory of economies of scale, the relationship between teacher qualifications and school district size is highly nonlinear. That is, the positive correlation diminishes significantly with size.

Teacher qualifications are also a measure of an educational input (in terms of quality) rather than an educational outcome, thus it is not necessary to control for the socio-economic characteristics of the student body. It is possible, though, that some districts have relatively more teachers with advanced degrees only because the area is attractive to people with advanced degrees and/or it is easier to obtain advanced degrees in the area. To account for this possibility, the qualification-size correlation is also estimated controlling for the percentage of residents with advanced degrees. This reduces the qualification-size correlation somewhat, but it is still very strong.

**Attendance**

One of the risks of larger school districts is that they may weaken student social networks, which could be manifested in things such as reduced attendance rates. The attendance-size correlation coefficients reported in Table 1 reveal an interesting pattern. Although a negative correlation seems more likely, when there is no control for socio-economic characteristics the correlation between attendance rates and the number of students enrolled per grade is hump-shaped like in Figure 2. The linear correlation coefficient is positive, but not large enough to be statistically different from zero. In the nonlinear case, though, the correlation is strongly positive initially but diminishes significantly with size.

The attendance-size correlation coefficients change considerably, however, when controlling for the socio-economic characteristics of the school districts. Evidently the observed hump-shaped pattern in attendance rates is mostly a by-product of the demographic characteristics of the districts rather than an effect of district size. In particular, it appears that relatively low median family income in the small districts is the most important reason for their relatively low student attendance rates. When controlling for socio-economic factors, the overall attendance-size correlation is negative, although not statistically different than zero (and this correlation is slightly weaker when using either population per road mile or transportation cost per student instead of population per square mile as the measure of population density).

**High School Dropout Rate**

The greater anonymity and weaker social networks in larger school districts could also be manifested in higher dropout rates. Indeed, numerous studies of other states have documented a positive correlation between dropout rates and size, although there is considerable debate over whether this correlation remains after properly controlling for socio-economic characteristics. A positive correlation between size and dropout rates is shown in McNeal (1997), Funk and Bailey (1999), and Lee and Burkham (2001). Gardner et al. (2000) found that the positive correlation remains even after controlling for the number of students eligible to receive free or reduced school lunches. On the other hand, Kennedy (1989) found no correlation between size and dropout rates, and Rumberger and Thomas (2000) found that the correlation between dropout rates and size is negative when rigorously controlling for student demographics.

The evidence for Maine is consistent with the above research. When there is no control for socio-economic characteristics the correlation between dropout rates and school district size is positive. Moreover, as one would probably expect, the relationship is nonlinear. Rising dropout rates appear to become a problem only as districts become very large. Indeed, practically all the dropout-size correlation in Maine is due to the high dropout rate in the state's one relatively large school district (Portland, with 74% more enrolled students than the next largest district, had the second highest dropout rate). Over the range of most school district sizes in Maine (all but Portland have less than 350 students enrolled per grade), dropout rates do not appear to be an issue.

The observed positive dropout-size correlation appears to be at least partly due to differences in socio-economic characteristics. The dropout-size correlation is not statistically different from zero when controlling for school district demographics. When demographic variables are incorporated, the best predictor of dropout rates is median family income in the district.

**Plans for College**

An increasingly important role of K-12 education is to prepare young people for higher education. Although we do not have data on college preparedness, a rough indicator of it is the proportion of high schools seniors who report intentions to go to college. Practically every senior in the state completes a questionnaire regarding post-graduation plans and their responses are reported by the Maine Department of Education.

There is a positive correlation between high school seniors' college plans and school district size. This correlation, however, appears to be entirely due to variation in socio-economic characteristics across districts.[14] The correlation is essentially zero after controlling for these differences. The average educational attainment of residents living within the district is by far the best predictor of the percentage of seniors planning to attend college. The percentage of students eligible for free and reduced school lunches is also a strong predictor.

**Home Schooling**

Many factors influence the decision to home school. One possible factor is the perceived quality of the area school system. At least some decisions to home school may indicate at least some level of dissatisfaction with the school system.

[14] This is consistent with the findings in Gardner et al. (2000). To be specific, they found that California students from "large" high schools (all larger than any school in Maine) were significantly more likely than students from "small" high schools (intermediate size by Maine standards) to take the Scholastic Aptitude Test (SAT) college-entrance exam. They also found that the students from the large schools had significantly higher SAT scores. But much of these differences do not remain after controlling only for the percentage of students eligible for free and reduced school lunches.

There is negative correlation between the percentage of resident students in the district that are home schooled and the number of students enrolled per grade. This correlation is somewhat nonlinear. That is, the home schooling-size correlation is more pronounced at the low end of the district-size scale. Much of this correlation, however, goes away when controlling for socio-economic factors. The best single predictor among school district demographics is the percentage of single-parent households. Evidently, and not surprisingly, single parents are unlikely to home school.

**Crime**

Welsh et al. (2000) and Harrison (2003) found that rates of student violence and school crime increase with high school size. Moreover, the Welsh et al. study found that this positive correlation remained even after controlling for local crime rates and poverty. This study, however, examined Philadelphia schools and the Harrison study examined New Jersey schools. Education is organized on a much smaller scale in Maine than in Philadelphia or New Jersey (e.g., the average school district in New Jersey is three times larger than the average district in Maine).

To explore this issue in Maine we examined the correlation between the juvenile arrest rate and school district size. The juvenile arrest rate does not directly measure behavior problems in and around schools and it may reflect policies unique to the district's police department. However, it is the best indicator that we could obtain. The juvenile arrest rates for school districts are computed using 1999 data from the Maine Department of Public Safety (juvenile attests) and the U.S. Census Bureau (number of juveniles). We were able to obtain juvenile arrest rates for 125 of the 227 school districts that operated schools.

The arrest-size correlation coefficients in Table 1 reveal an interesting pattern. When not controlling for socio-economic characteristics, there is essentially no correlation between juvenile arrest rates and the number of students enrolled per grade. The linear correlation coefficient is positive but not even close to being statistically different from zero. There is essentially no nonlinearity in the relationship.

There is a surprising correlation between juvenile arrests and school district size, however, when taking the socio-economic characteristics of the districts into account. As one would expect, the adult arrest rate is very closely correlated with the juvenile arrest rate. After controlling for this, juvenile arrests are negatively correlated with district size. This surprising negative correlation is not statistically different than zero in the linear case, but is statistically significant in the nonlinear case. That is, after controlling for the adult arrest rate, there is a hump-shaped pattern between the juvenile arrest rate and school district size (this result is also found when using the area crime rate instead of the adult arrest rate). Evidently there are relatively fewer juvenile arrests in the very small and relatively large school districts in Maine once area crime is taken into account. This result is difficult to explain. One might expect a positive correlation, no correlation, or even a U-shaped correlation.

**Maine Educational Assessment**

The most common measure of educational quality is standardized test scores. Numerous studies have examined the relationship between test scores and size, but the findings are generally conflicting. If there is one clear result in this literature, it is that family background has a much more important effect on a student's scores than school size (and just about everything else to do with schools).

Several studies found positive effects of size on test scores. Gardner et al. (2000) found that high school size had a significant, positive effect on Scholastic Aptitude Test scores, although this study only had limited controls for family background. Schreiber (2002) found that school size positively impacted performance on the Third International Mathematics and Science Study, even when including a very rich set of control variables. Duncombe et al. (1995) found that school district size was positively correlated with the percentage of high school students who passed the New York Regents Examination. Bradley and Taylor (1998) and Barnett et al. (2002) also found positive relationships between school size and student test achievement.

Other studies found the opposite; they report negative effects of size on test scores. Lee and Smith (1995) found that school size had a small but significant negative effect on two-year achievement gains on standardized math and reading tests. Harrison (2003) found that pass rates on New Jersey's High School Proficiency Exam were higher in schools with 500 or fewer students than in schools with 1,500 or more students (none of Maine's schools are this large). Driscoll et al. (2003) found that district size had a small negative impact on standardized test performance in elementary and middle schools, but no significant impact on high schools. Lamdin (1995) found no significant relationship between the size of public elementary schools and student performance.

The Maine Educational Assessment (MEA) is administered annually to all 4$^{th}$, 8$^{th}$, and 11$^{th}$ grade students in schools that receive public funds. It consists of seven subject tests: Reading, Writing, Mathematics, Science, Social Studies, Health, and Visual & Performing Arts (the latter three were eliminated in 2003-04). Table 2 reports the correlation between the number of enrolled students per grade and the average score of

"The Three Rs": Reading, Writing, and Mathematics. We also computed the correlations between school district size and each of the seven subject tests, as well as the average of all seven subject tests. The correlation coefficients of these alternative measures were extremely similar to "The Three Rs" measure. To avoid redundancy, we only reported the latter measure in Table 2.

**Table 2**
**Correlations between Standardized Test Scores and School District Size**
**Averages in Maine from 1998-99 though 2002-03**

| | | Linear Specification | Nonlinear Specification | |
|---|---|---|---|---|
| **Outcome** | | **Enrollment** | **Enrollment** | **Enrollment$^2$** |
| 4th Grade | without S-E controls | 0.2052 | 0.1758 | -0.0921 |
| | | *0.003* | *0.011* | *0.184* |
| | with S-E controls* | 0.0282 | 0.0063 | 0.0069 |
| | | *0.699* | *0.931* | *0.925* |
| 8th Grade | without S-E controls | 0.1365 | 0.1185 | -0.0632 |
| | | *0.056* | *0.098* | *0.379* |
| | with S-E controls* | -0.1544 | -0.1143 | 0.0508 |
| | | *0.037* | *0.125* | *0.496* |
| 11th Grade | without S-E controls | 0.2323 | 0.2538 | -0.1614 |
| | | *0.012* | *0.008* | *0.083* |
| | with S-E controls* | 0.0454 | 0.0458 | -0.0280 |
| | | *0.641* | *0.640* | *0.775* |

Notes:
P-values are reported in italics under the correlation coefficients.
* These correlations control for the percentage of residents with an associates degree or higher, median family income, population density, percentage of families with a single parent, percentage of students eligible for free and reduced school lunches, and being an Indian school district.

When there is no control for socio-economic characteristics of the school districts, the relationship between average MEA scores and school district enrollment is positive, but diminishing slightly. The linear correlation coefficients are positive and usually statistically significant. In the nonlinear case, the correlation is positive initially and diminishes somewhat as district size increases. This is true in all 21 cases (i.e., for all seven subjects for all three grades).

The linear MEA-size correlation coefficients are statistically significant at the 10% level in 16 of the 21 cases. In the nonlinear case, the positive correlation with enrollment is statistically significant in 13 of the 21 cases, and the negative correlation with enrollment squared is statistically significant in four of the cases (each of these is an 11th grade test). The linear correlations are always strongest for the 11th grade and weakest for the 8th grade, with only two exceptions (the 4th grade correlation for Social Studies is very slightly larger than for the 11th grade, and the 8th grade correlation for Science is slightly larger than for the 4th grade). All seven correlations are statistically significant for the 11th grade, but only three are statistically significant for the 8th grade. Although the orderings are not uniform over all grades, the correlations with district size are generally strongest for Writing, followed by Reading. The correlations are generally weakest for Mathematics and Science.

When socio-economic characteristics of the school districts are taken into account, the correlations between average MEA scores and school district enrollment per grade essentially disappear, with the puzzling exception of the 8th grade which is discussed below. That is, just about all the positive relationship between test performance and district size is a consequence of the demographic characteristics in the school districts. After accounting for these characteristics, there are no statistically significant correlations between district size and any of the seven subject tests in the 4th and 11th grades. The only variable that has a significant correlation with average 11th grade scores (when simultaneously considering all the variables) is average educational attainment in the district. The 4th grades scores, however, are significantly correlated with the percentage of students eligible for free and reduced school lunches and median family income.

The 8th grade MEA scores behave differently than those of 4th and 11th grade. The 8th grade scores are negatively correlated with district enrollment when controlling for socio-economic characteristics. This negative correlation is statistically significant in four of the seven subject areas and in the overall average. The percentage of students eligible for free and reduced school lunches, average educational attainment of adults within the district, population density, and median family income are all significantly correlated with average 8th grade scores (when simultaneously considering all the variables).

The negative correlation between the 8th grade MEA scores and district size after controlling for socio-economic variables is somewhat puzzling. This negative correlation is attenuating in six of the seven subject areas, although it is not statistically significant. This implies that 8th grade MEA scores are highest at the lower and upper ends of the size scale, and are lowest in middle. This result is difficult to explain because if size negatively affects educational performance, then, if anything, this effect should worsen as district size grows. But the data suggests that it attenuates slightly as size increases. Given that this result is difficult to reconcile, and that it is inconsistent with the results for the 4th and 11th grades, we are reluctant to attach much significance to this finding.

**Summary**

The above results present us with a range of angles from which to assess the relationship between school district size and educational quality. One could emphasize a particular angle depending on what one thinks is the most important aspect of education or one's predisposition to consolidation. However, the most reasonable conclusion is based on the multiple quality indicators taken together. The conclusion to be drawn from the indicators as a group, both in this analysis and in previous studies, is that there is very little relationship between educational quality and school district size over the range of district sizes relevant for Maine (ie, up to about 350 students per grade). There is no firm basis on which to argue that educational quality would generally improve or worsen if Maine's small school districts consolidated. In general, greater consolidation of Maine's educational resources is likely to improve some dimensions of educational quality. It is also likely to harm others. But, as long as we are taking about the school district sizes relevant for Maine, most dimensions of educational quality would be little effected by greater regionalization.

If differences in school district socio-economic characteristics are taken into account, then as the number of students enrolled per Maine school district increases:

- The teacher/student ratio declines. Most of this decline occurs at the very low end of the district-size scale (less than 50 students per grade). And most (if not all) of this is probably due to fuller classes rather than larger classes.
- The percentage of teachers with advanced qualifications rises. Most of this rise also occurs at the very low end of the scale.
- Student attendance, high school dropout rates, intentions to go to college, home schooling, juvenile crime, and standardized test scores generally do not change significantly.

There are, of course, other important dimensions of educational quality that were not examined above. At least two of these dimensions are particularly important for the issue of school district consolidation: the ability to offer a variety of courses, and participation in extracurricular activities. Organizing educational resources on a larger scale should improve the breadth and depth of curricular and extracurricular offerings.[15] But it is also likely to reduce the relative proportion of students participating in at least some extracurricular activities (except perhaps when the initial scale of operation is so small that many activities cannot even be offered).[16] Thus, regionalization decisions present some important tradeoffs in educational experiences.

Although the weak and often conflicting effects of district size on educational quality are disappointing in the search for concrete answers to an important policy question, they are perhaps not that surprising. If there were a dramatic correlation between overall educational quality and district size, it would be obvious to parents, teachers, and concerned citizens that educational resources should be organized on a different scale. The size decision would be simple. Clearly it is not.

[15] Indeed, this is one of the main reasons behind the significant push for school consolidation in the middle of the last century. Conant (1959) summarizes this view: "The enrollment of many American public high schools is too small to allow a diversified curriculum except at exorbitant expense. The prevalence of such high schools--those with graduating classes of less than one hundred students--constitutes one of the serious obstacles to good secondary education throughout most of the United States." Riew (1966) and Monk (1990) found that larger public high schools in Wisconsin and New York offered significantly more courses. Fairman et al. (2003) provide evidence indicating that curricular and extracurricular offerings are greater in Maine high schools with more than 188 students per grade.

[16] Barker and Gump (1964) found that the number of extracurricular activities in available to high school students grew with school size, but not in proportion to the increase of students. Hence, the percentage of students participating in activities decreased as enrollment increased. Schoggen and Schoggen (1988) also found that increasing school size increases the percentage of students left on the sidelines.

## VI. In-Depth Analysis of Educational Scale and Costs in Maine

Sections III and IV presented data indicating that there may be significant unrealized economies of scale in some of Maine's school districts. In other words, the relatively small size of many school districts may cause their cost per student to be higher than necessary to achieve the quality of education that they offer. Or equivalently, their small size may cause the quality of education to not be as high as it could be for the price paid by taxpayers. In this section we quantify this notion.

Quantifying the effects of size on costs requires the use of multivariate regression analysis to estimate an equation that best fits the data shown in Figure 4. The theory and data discussed earlier indicate that the relationship between operating cost per student (abbreviated as C) and district size (abbreviated as S) is nonlinear. We describe this with a quadratic equation:

$$C_i = a + ß_1 S_i + ß_2 S_i^2.$$

School district size, S, is measured as the number of students enrolled per grade.[17] The subscript i denotes the individual school districts (i.e., the values of C and S are different in each district), and a, $ß_1$, $ß_2$ are parameters to be estimated.

The data and theory indicate that school districts without high schools (NHS districts) benefit from the economies of scale realized in the larger districts where they send their high school students (HS districts). Moreover, the extent of economies of scale in primary education is probably quite different than the extent in secondary education. It seems likely that there are much more economies of scale in high school education

[17] Size is measured as enrollment per grade rather than just overall enrollment (as shown in Figure 4) to account for the many school district configurations in Maine (i.e., most are either K-12 or K-8, but some are K-6, K-5, 9-12, and other configurations). The results are essentially the same using either measure, although the variation in the data is explained slightly better by students per grade.

because there is a wider variety of courses, extracurricular activities, staff, etc. Therefore, it is appropriate to allow for the cost curves to be different for districts with and without high schools.[18] An indicator variable, D, is therefore created for the NHS districts. This variable is equal to one for HS districts and equal to zero for districts with high schools. The intercepts of the curves are allowed to differ by adding D to the equation to be estimated. The slopes of the cost curves are allowed to differ by interacting D with the S terms. Thus, the estimating equation is

$C_i = a + \delta D_i + ß_1 S_i + \gamma_1 D_i S_i + ß_2 S_i^2 + \gamma_2 D_i S_i^2.$

d, $\gamma_1$, $\gamma_2$ are additional parameters (regression coefficients) to be estimated.

The estimating equation fits the data slightly better when using the natural logarithm of C. This transformation fits the data better because it allows for greater nonlinearity in the cost curve, particularly at the low end of the size scale. This changes the interpretation of the regression coefficients. When using lnC, the estimated regression coefficients show the percentage change in per student cost (rather than the dollar change). Thus, ß + ?S is the rate of cost change as enrollment per grade rises. As in all regression analyses, there is also unexplained variation (abbreviate as e) in cost per student (due to differences in efficiencies, prices, etc.). Thus, the final regression equation is

$\ln C_i = a + \delta D_i + ß_1 S_i + \gamma_1 D_i S_i + ß_2 S_i^2 + \gamma_2 D_i S_i^2 + e_i.$

The left side of Table 3 reports the results of estimating this equation from Maine school district data averaged from 1998-99 through 2002-03 (dollar figures are adjusted

[18] We also experimented with allowing the cost curves to be different between other grade configurations (e.g., not operating grades K-4, or grades 7-8, etc.), but the data did not indicate that there were significant differences. The results are essentially unchanged when including other grade configurations.

**Table 3**
**Estimated Effects on Operating Cost per Student (in percent)**
**Maine School Districts from 1998-99 though 2002-03**

| | without Controls | | with Controls | |
|---|---|---|---|---|
| **Outcome** | **with H.S.** | **without H.S.** | **with H.S.** | **without H.S.** |
| Enrollment | -0.151 | -0.725 | -0.176 | 0.360 |
| | *0.000* | *0.000* | *0.000* | *0.000* |
| Enrollment$^2 \times 100$ | 0.027 | 0.296 | 0.015 | 0.120 |
| | *0.000* | *0.000* | *0.009* | *0.003* |
| No High School | | 6.216 | | -2.658 |
| | | *0.315* | | *0.495* |
| Indian District | | | 24.494 | |
| | | | *0.000* | |
| Property Value per Student (in thousands) | | | 0.011 | |
| | | | *0.001* | |
| Average Faculty Salary (in thousands) | | | 1.520 | |
| | | | *0.000* | |
| Percentage of Teachers with Advanced Degrees | | | 0.267 | |
| | | | *0.000* | |
| Teacher/Student Ratio (in hundredths) | | | 5.293 | |
| | | | *0.000* | |
| $R^2$ | 0.203 | | 0.761 | |

Note:
P-values are reported in italics under the regression coefficients.

for inflation to January 2003 values).[19] As discussed above, the estimated regression coefficients are reported as percentage changes in per student operating cost per unit change in the explanatory variable. Thus, the 6.216 coefficient estimate for NHS districts means that, holding enrollment per grade constant, Maine's NHS districts average 6.2% higher operating cost per student than HS districts (although its p-value indicates that it is

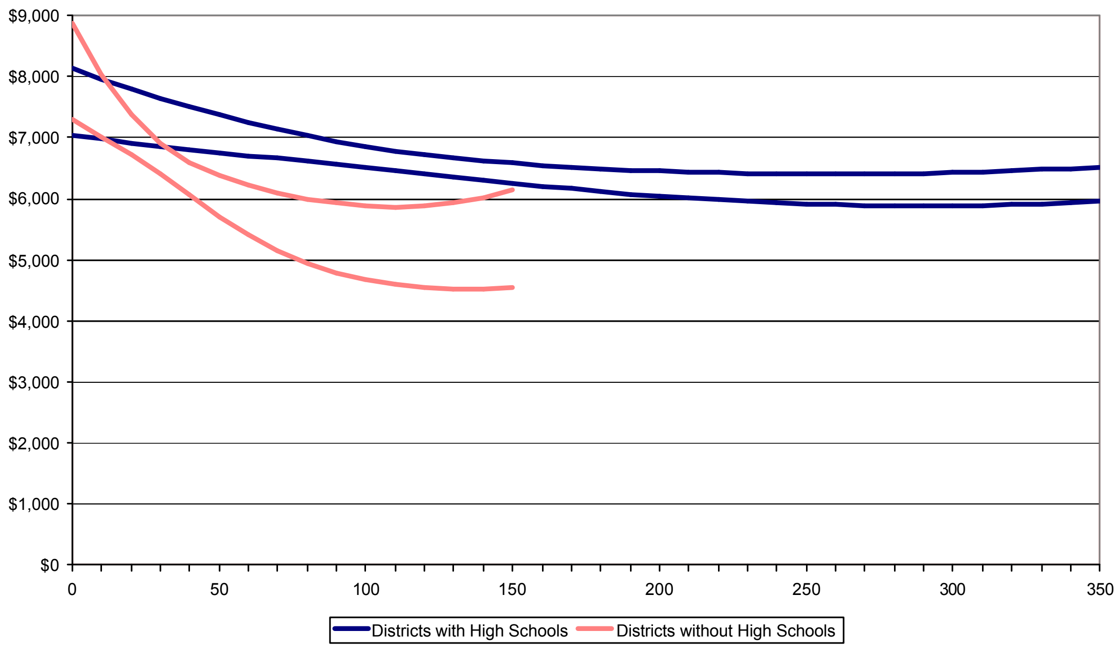
[19] We also estimated the cost curves using each year of data using appropriate techniques for longitudinal data (also known as panel data). Not surprisingly the results were very similar, although the estimated economies of scale were somewhat larger (and slightly more precisely estimated) using this approach.

not estimated precisely enough to be statistically different than zero). The p-values (the probability that the coefficient is zero) corresponding to the coefficient estimates have been corrected for heteroscedasticity. As reported on the bottom row of Table 3, 20.3% of the variation in the logarithm of operating cost per student is explained by just five variables measuring school district size.

As expected given the earlier discussion of economies of scale, the coefficients on S are negative and the coefficients on $S^2$ are positive, meaning that the estimated cost curves are U-shaped. Also as expected, the estimated U-shape is much more pronounced for the NHS districts. Figure 5 illustrates the estimated cost curves over the range of most school district sizes in Maine (only one district averaged more than 350 students per grade, and only one district without a secondary school had more than 110 students per grade). The cost curves are obviously not estimated with perfect precision, thus they are shown in the form of 95% confidence intervals (which have been corrected for heteroscedacticity). The actual cost curves can be expected to lie between these bounds with 95% probability. These curves indicate that most of Maine's school districts lie on the downward-sloping parts of the cost curves, indicating that there are unrealized economies of scale in public education in Maine. The estimated minimum-cost enrollment per grade is 276.3 students in HS districts (8 of Maine's 117 HS districts are this large), and 122.3 students in NHS districts (1 of Maine's 89 NHS districts is this large).

Costs obviously depend on more than just school district size. Thus, the right side of Table 3 reports the results when controlling for other factors that are likely to affect costs. If other factors that affect cost vary systematically with district size, then the left-

**Figure 5**
**Estimated Cost Curves without Controls**
**95% Confidence Intervals**




side estimates may be biased (i.e., there could be an "omitted-variables bias"). As in the earlier discussion about the relationship between educational quality and size, it is possible that the observed correlation between per student cost and size could be the by-product of both being correlated with something else, rather than size having a real causal effect.

There are at least three types of factors that may significantly affect educational costs: revenue sources, regional cost variations, and quality factors. It is particularly important to try to control for quality. To correctly measure economies of scale by comparing costs at different sizes one needs to try to compare apples to apples as much as possible.

One control is an indictor variable for Indian school districts, which have much greater federal funding than other school districts. Assessed property value per student is another control, because local property taxes are the primary revenue base for most school districts. Average faculty salary is included for two reasons: to capture regional price differences (i.e., area cost conditions) and to control for average experience of teachers (i.e., quality). The percentage of teachers with advanced degrees and the teacher/student ratio are also included to control for quality differences. One could argue that teachers per student is a flawed measure of quality since less-than-full classes could be part of the problem of very small school districts. Nonetheless, we think that it is best to include it as a control. It is worth stressing, though, that the estimated effects of school district size hold teacher qualifications, teachers per student, and faculty salaries, constant.

We experimented with a host of other control variables, such as the percentage of students in special education programs, district type (i.e., single municipality, School Administrative District, Consolidated School District), average annual change in the number of students enrolled per grade (both in actual and absolute terms), having pre-kindergarten programs, having full-day kindergarten, attendance rates, the percentage of home schooled students, college intentions, dropout rates,[20] and socio-economic variables such as median family income, average educational attainment, etc. We did not include them in the cost equation reported on the right side of Table 3 because none of them were

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[20] Some researchers advocate using cost per graduate, rather than cost per student, to account for educational quality. For example, a widely cited study by Stiefel et al. (2000) found that "small" (up to 600 students) New York City high schools had roughly the same cost per graduate as the "large" (over 2,000 students) schools, and a lower cost per graduate than the "medium" size schools. There is a fundamental flaw with this measure, though. It imposes the implicit value judgment that K-12 education has no value unless a high school diploma is earned. It also implies that General Education Development tests (GEDs) have no value. According to this measure the sooner those not receiving diplomas drop out the better. Obviously no one is espousing these views; but these are logical conclusions from this measure. The appropriate way to account for this potentially important dimension of quality is to simply include the dropout rate (or completion rate) as a control variable in a per-student cost equation.

consistently statistically significant,[21] they did not affect the estimated coefficients on district size, and, most importantly, many of them caused observations to be lost. For example, if we included college intentions as a control variable then all observations from districts without high schools would be lost. Standardized test scores are the most commonly used measure of educational quality, thus we also tried average MEA scores as a control variable in the cost equation. None of the scores came close to being statistically significant or effecting the results, and including them also caused observations to be lost (15 observations were lost even when we used only the 4th grade scores).

Perhaps the insignificance of these other potential control variables is not that surprising. As reported at the bottom right of Table 3, the ten variables included in the estimated cost equation (five variables measuring school district size and five control variables) already explain 76.1% of the variation in the logarithm of operating cost per student. The estimated coefficients on the control variables are as expected. Holding everything else constant, cost per student is significantly higher in Indian school districts and increases significantly when assessed property values increase, faculty salaries increase, teacher qualifications increase, and teacher/student ratios increase.

The estimated cost curves are noticeably effected by the inclusion of these controls. In particular, the cost curves indicate greater economies of scale than when there are no controls. This is illustrated in Figure 6. The addition of the control variables causes the cost curves to be downward sloping over a larger range because three of the control variables are significantly correlated with both cost and size.

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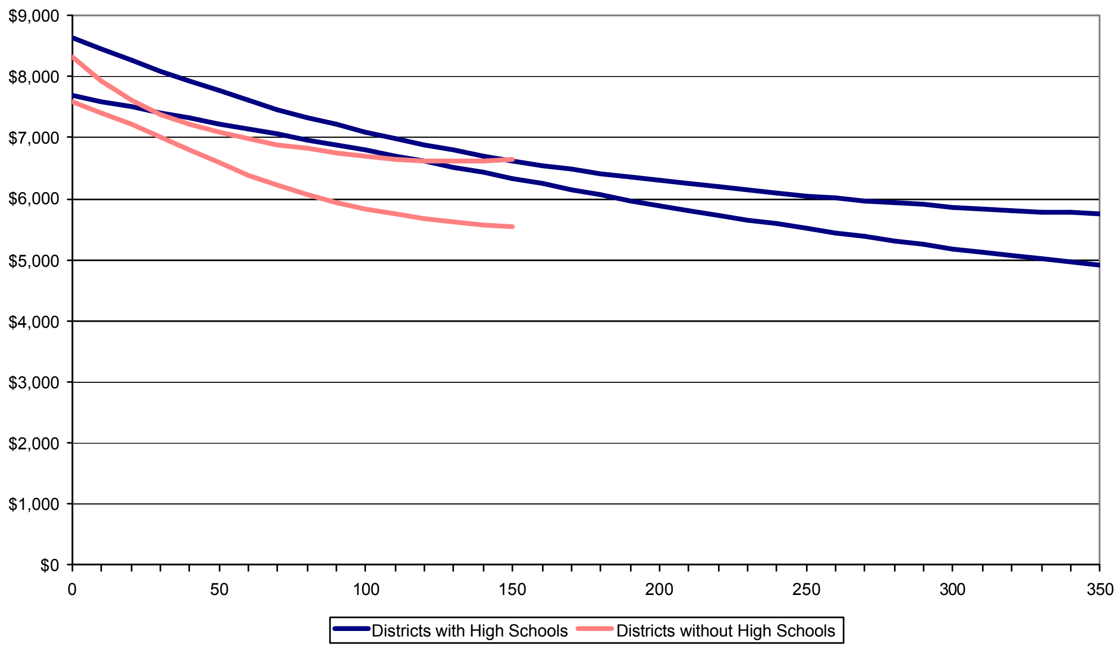
[21] Depending on which control variables were included, some of these variables were statistically different from zero in some cases, but not in others. The five control variables reported in Table 3 were the only

Figure 6
Estimated Cost Curves with Controls
95% Confidence Intervals




In particular, the data indicate that higher assessed property values per student (i.e., larger tax bases) lead to greater spending per student, and property values per student are generally higher in the larger districts. Thus, the raw data understate the true extent of the economies of scale. Evidently some of the observed flattening out of the cost curve is really due to larger tax contributions to local education in the relatively larger school districts.

The data also indicate that faculty salaries are generally higher in the larger school districts (even when controlling for the proportion of teachers with advanced degrees), and higher salaries obviously affect costs. Cost conditions are apparently unfavorable in school districts with larger numbers of students, on average. Thus, there is another important reason why the raw data understate the real extent of economies of scale.

ones that were consistently significant.

In addition, as shown in the previous section, average teacher qualifications are generally higher in the larger school districts, and teachers with higher qualifications cost more. This is a third reason why the raw data do not reveal the full magnitude of potential economies of scale.

One of the control variables, however, works in the opposite direction. As shown earlier, the teacher/student ratio declines with school district size. A declining teacher/student ratio obviously reduces cost per student. Thus, failure to hold the teacher/student ratio constant causes the extent of economies of scale to be overstated.

The net effect of these control variables is to reveal larger unrealized potential economies of scale than indicated by the raw data. When controlling for these variables the estimated minimum-cost enrollment per grade is 574.3 students in districts with high schools (compared to 276.3 without the controls), and 149.4 students in districts without high schools (compared to 122.3 without the controls). In each category, Maine has just one school district near these cost-minimizing enrollment levels.

The net effect of including the control variables in the estimated cost equation can be seen clearly in Table 4. This table reports the estimated rates of change as enrollment per grade increases at various levels of enrollment per grade. As mentioned earlier, the rate of cost change is ß + ?S. The effect of district size on cost depends on the where one is on the district-size scale; meaning the effect is nonlinear. Table 4 highlights this feature. For example, the rightmost column shows that for a district without a high school, one additional student per grade (i.e., an additional 9 students in a K-8 district) reduces operating cost per student by 0.336% when there are 10 students enrolled per grade (this translates to $26.45/student for a K-8 district), but only 0.119% when there

**Table 4**
**Estimated Rates of Change in Operating Cost per Student (in percent)**

| Enrollment per Grade | without Controls with H.S. | without Controls without H.S. | with Controls with H.S. | with Controls without H.S. |
|---|---|---|---|---|
| 10 | -0.145 | -0.666 | -0.173 | -0.336 |
| 20 | -0.140 | -0.606 | -0.170 | -0.312 |
| 30 | -0.134 | -0.547 | -0.167 | -0.288 |
| 40 | -0.129 | -0.488 | -0.164 | -0.264 |
| 50 | -0.123 | -0.429 | -0.161 | -0.239 |
| 60 | -0.118 | -0.369 | -0.158 | -0.215 |
| 80 | -0.107 | -0.251 | -0.152 | -0.167 |
| 100 | -0.096 | -0.132 | -0.145 | -0.119 |
| 120 | -0.085 | -0.014 | -0.139 | -0.071 |
| 150 | -0.069 | 0.164 | -0.130 | 0.002 |
| 200 | -0.042 | | -0.115 | |
| 250 | -0.014 | | -0.099 | |
| 300 | 0.013 | | -0.084 | |
| 400 | 0.040 | | -0.053 | |

are 100 students per grade ($7.63/student).

The cost efficiencies from greater size occur mainly at the very low end of the size scale. Per-student cost declines up to 574 students per grade (up to 149 students for districts without a high school) when including the control variables in the cost equation, but the cost declines cease to be statistically significant (at the 95% confidence level) at 393 students per grade (118 without a high school). That is, the estimated cost curve is essentially flat once enrollment reaches roughly 400 students per grade (120 without a high school).

The nonlinearity in the cost curve means that estimates of unrealized economies of scale can only be estimated on a case by case basis. The potential cost savings are not simply the difference between estimated cost for the average district size and the estimated cost at the cost-minimizing size. As stressed above, the potential per-student cost savings are clearly greater when moving along the downward-sloping part the cost curve, e.g., from 20 to 60 students per grade, than when moving along a point nearer to the flat part of the curve, e.g., from 200 to 240 students per grade. Thus, the coefficient estimates reported in the right side of Table 3 (i.e., the estimates when the control variables are included in the cost equation) were applied to the average enrollment level of each of the 204 (out of 206) districts with less than the cost-minimizing enrollment levels and to the cost-minimizing enrollment levels for districts with and without high schools. The differences between the calculated per-student cost for each district and the per-student cost calculated at the cost-minimizing enrollment were then computed. This yields the difference in per-student cost that is due solely to the relationship of actual district sizes and the cost-minimizing size. These differences were then multiplied by the average number of students enrolled in each district. This yields an estimate of the dollar value of unrealized economies of scale.

The above computations reveal potential unrealized economies in Maine's public education system of $270,854,958 million per year. This is just under 20% of the annual (inflation-adjusted) total operating costs from 1998-99 to 2002-03. In other words, public education in Maine costs roughly $270 million, or 20%, more than it would if all school districts were operated at the cost-minimizing enrollment.

This $270 million figure should not be interpreted as the amount of likely cost savings from consolidation of educational resources in Maine. Geography clearly limits the possibility of reorganizing all school districts to the cost-minimizing enrollment level. Furthermore, the experiences of other states suggest a tendency for the potential administrative cost savings from consolidation to be absorbed into other aspects of a district's budget (Streifel, et al. 1991 and Truett 1999). The $270 million figure should be interpreted as an estimate of the amount that is at stake in the consolidation debate. Geographically rational school district consolidations, accompanied by meaningful administrative restructuring and fiscal discipline, may only be able to achieve a fraction of this amount. But given the amount at stake, a fraction is far from trivial.

Three points about these estimates deserve emphasis.

First, the estimated cost savings of larger district sizes (over the range of sizes relevant for most of Maine) hold teacher qualifications and the teacher/student ratio constant. If some of the cost efficiency from realizing greater economies of scale is put into educational quality through hiring relatively more teachers with advanced degrees and so forth, then the observed cost savings from consolidation of educational resources will be smaller than indicated above. But on the other hand, if consolidation of school districts leads to more full classes and hence higher teacher/student ratios, then the observed cost savings would be substantially larger than indicated by these estimates.

Second, the cost-savings estimate assumes that the hypothetical districts of cost-minimizing size would offer services comparable to those currently offered by similarly-sized Maine school districts. In other words, the cost savings estimate accounts for potential increases of expenditures on items not included in the regression equation, such as expenditures on extracurricular activities.

Third, advocates for the status quo in public education in Maine sometimes argue that very small school districts are already achieving much of the potential economies of scale through regional cost-sharing arrangements, thus consolidation is not necessary to achieve the efficiency gains. We do not doubt that cost-sharing is indeed occurring already. But to the extent that it has happened, its effect is already in the data. The potential cost savings above are in addition to the regionalization arrangements in place from 1998-99 through 2002-03.

## VII. Conclusion

The in-depth analysis of costs and school district size confirms that there are substantial unrealized economies of scale in Maine's public school districts. There is considerable duplication of spending on administration and facilities that would not exist if education were organized on a larger scale in some areas. Furthermore, the larger districts would not decrease the quality of students' educations. Cost savings could be converted into more resources for student instruction and to increase the breadth of curricular and extracurricular opportunities

In general, the quality of education in Maine does not vary greatly across school districts of various sizes. But this is not true for costs. One reason for this may be statewide standards for educational quality (MEAs, Learning Results, etc.) that have not existed for costs. Until very recently, state subsidies to local education were based primarily on past expenditures. As enrollment levels declined in many areas, this essentially created a subsidy to smallness. The adoption of a new funding formula in

2004 may change this equation. The new formula ties state funding more directly to enrollment levels. Future analysis will be needed to assess the effect of this change, but it seems likely that it will move per-student costs closer to uniformity, either through consolidations like those described herein or through other cost-saving methods.

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