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ABSTRACT — Because of declining demands for a number of urban public services, public officials have had to make difficult adjustments towards more efficient levels of these services. One such adjustment of very great concern has been the modification of education services in response to declining enrollments. This study investigates the impacts of changing enrollments, enrollment scale, capacity utilization, and age of schools on per student instructional costs and per student cost of land and buildings. The resulting model has been estimated for Duluth, Minnesota primary schools and these regression estimates provide a good explanation for per student instructional costs. The residuals for the per student instructional costs are also examined. These residuals provide an important source of information for making managerial decisions regarding service levels since they indicate which schools are performing above or below cost norms.

Introduction

A set of research questions of significant interest to urban resarchers center on the measurement of the production relationships of goods provided by the public sector along with resulting cost relationships. An especially troublesome problem is in the definition and measurement of the outputs of urban public services in order to compare costs to appropriate output levels. Such measurement and estimation hold major implications for public policy, especially in this age of high concern over levels of public expenditures and pending cutbacks.

One service that has received some attention in recent years has been that of public education, where enrollment can be used as an imperfect measure of output. Such a measure, adjusted for quality, can usefully be applied to policy decisions. A number of studies have appeared in the literature in recent years dealing with the average cost of elementary and secondary education. These studies have examined costs at both the school district and individual school levels. In almost all cases, the technique has been based upon cross section regression analysis. The cross section approach has generally used observations from districts, or schools from districts, that fall under more than one political jurisdiction.

Not surprisingly, the results have been somewhat diverse. Many of the cross sectional studies that dealt with districts have found little or no economies of scale (i.e., declining costs at higher enrollment levels) relative to the size of district-wide enrollments. A classic study of this type was conducted by Werner Z. Hirsch (1).

Soon after Hirsch's article, a number of researchers began to explore costs for individual schools. Most of these were oriented towards the secondary level. For example, Riew (2) applied the cross section regression technique to senior high schools in Wisconsin. The dependent variable was the per pupil cost, and the independent variables included average teacher's salary; number of credit units offered; average number of courses taught per teacher; percentage of classrooms built after 1950; operating expenditures; changes in enrollment between 1957 and 1960; and enrollment. Of these seven variables, the first four represent adjustments for quality variation between schools. Studies oriented towards secondary schools require adjustment for quality differences because of significant differences in diversity of offerings, specialized programs, and other quality factors. Elementary schools generally have more uniform offerings and adjusting for quality in terms of courses is, therefore, less important.

The Riew study found that per student expenditures generally declined as enrollment increased from 200 to 900. Average expenditures began to rise when enrollment was between 900 and 1,100. Per unit costs fell again with enrollments from 1,100 to 1,600. Finally, costs stabilized at enrollments of about 1,600. The regression analysis was interpreted to find significant economies of scale for the high schools used in this study.

A related analysis was conducted by Cohn (3), who analyzed economies of scale for secondary schools in Iowa. Although Cohn used districts rather than individual schools, the vast majority of the districts in Iowa had only one senior high school. As in Riew's study, Cohn attempted to look at per pupil costs as a function of several factors, such as average teacher's salary and two quality variables, average daily attendance and an index of test scores over a three-year period. Like Riew, Cohn found significant economies of scale through the application of this cross section technique.

A similar study in Oklahoma by White and Tweeten (4) emphasized both transportation and education costs using a random sample of schools stratified by school district size. The authors included such factors as administrative and maintenance costs, pupil-to-teacher ratios, and achievement scores from examinations administered for the purpose of their study. They found that economies depend on the curriculum as well as on the nature (rural vs. urban) of the schools. Consolidation would be much more feasible, for example, in urban centers, where transportation is not as major a factor as it would be in rural areas. Consolidation did allow for a broader curriculum, and presumably, a higher quality of education.

Few articles have been written on the topic of economies of scale associated with grade school operations. This is somewhat surprising, since the grade schools do not generally have the diversity of offering that one would find in a high school situation. This should make comparisons more valid. One such study conducted by Hind (5) used several individual schools in a cross section study for the New South Wales area in Australia. Once again, the per pupil expenditures were used as a dependent variable and regressed against such factors as enrollment, the ratio of teachers in promotion positions to all other employees, the average annual salaries of non-promotable personnel, and dummy variables associated with staffing procedures and teacher shifting. Hind employed a second regression equation to analyze maintenance costs as they were affected by age of school buildings and enrollment. He found economies of scale in the maintenance costs up to a certain size, after which economies leveled off. He also found both economies and diseconomies

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of scale to exist for administration and instructional costs.

Data and Scope of this Study

Previous studies emphasized the use of secondary schools or districts. However, many specialized programs exist at the secondary level, requiring adjustments for quality differences across schools or districts. Similarly, schools or school districts may differ because they are located in various political jurisdictions. This will result in non-comparability in the quality of schools and significant administrative cost differences across cases. Lastly, schools serving various population densities because of urban versus rural locations have in the past been combined. A cross section regression must adjust for these factors with the use of additional variables to make a valid analysis of scale. In order to minimize these sources of quality variation, we have analyzed elementary schools, grades kindergarten through six, from a single school district in Duluth, Minnesota.

Although most studies discuss costs in the "quasi long-run," the cross section technique limits the time period to a single year's observations. Past studies relied on cross section analysis since scale of operation was not expected to be subject to the influence of time. However, with the rapid changes in enrollments of the past two decades, practical policy decisions about resource allocations have been made on a year-by-year basis. Since one of the major reasons for this study was to empasize the impact of changing enrollments upon per student costs, it was felt that time series data should be used.

We would have preferred examining enough years to measure both rising and declining enrollments in order to estimate whether zero growth was associated necessarily with minimum per student costs. However, we were only able to obtain consistent data for five years (1975-1980) and could only estimate the impact of declining enrollment upon per student costs. Moreover, because only five years and 24 schools were available, the cross section and time series data were pooled. The pooling technique, besides increasing the number of cases, allows for more variation in the variables chosen and can result in a better fit between actual and predicted values.

A number of the previous studies were also designed to provide some insight into the scale issue surrounding consolidation of schools into larger sizes when enrollments were rising. These studies used per pupil cost as a factor in consolidating schools. This paper looks more closely at the more recent development of school closings in the face of declining enrollments and examines the factors which should be considered in deciding when schools should be shut down.

Finally, most previous studies employ cross section observations (i.e., across schools) and use absolute levels of enrollment or changes in enrollment as an indicator of scale or changes in scale. This paper seeks to emphasize the impacts of changing enrollments on scale and costs by utilizing time series data collected from 1975 to 1980. By pooling both the cross sections (24 schools) and the time series (five years), it was felt that the dynamic effects on scale could best be measured.

Models to be Estimated and Results

Ordinary least square regression analysis was used to estimate the effects of enrollment upon per student costs. The ordinary least squares model was used rather than the more common error components model for pooled time series-cross section data. An important reason for this choice is that the dependent variables were defined on a per student basis, making schools comparable. This appears to be substantiated by an examination of the residuals, which seemed to indicate that the effect of school identity (i.e., heteroskedasticity) was unimportant.

Two separate analyses of per student costs were made. One analysis dealt with salaries (AVC), where salaries were felt to be influenced by enrollments. The other analysis, the present value of buildings (AFC), dealt with "sunk costs," which seemed more difficult to adjust to changing enrollments.

In the first set of two equations, the dependent variable deals with per student costs, which should be sensitive to enrollments (AVC). These costs are made up of various administrative, teacher, and staff salaries as well as instructional equipment, operating, and maintenance expenditures. The independent variables include enrollment, trend, age of school, and achievement test scores. Two major specifications of the AVC were estimated. The first specification was referred to as a scale analysis since it was expected that a standard, u-shaped cost curve might exist for various enrollment levels. Accordingly, equation (1.1) in Table 1 contains both a linear and quadratic term for enrollment. The second specification was referred to as a utilization analysis because it contains a schoolroom capacity utilization term. From the scale analysis, optimum school size can be estimated. If the partial derivative of variable costs per student is taken with respect to enrollments and set equal to zero, a relative minimum of costs can be found:

$$\frac{\delta VC}{\delta ENR} = -1.032 + 0.002ENR = 0.$$

Minimum per student costs in the Duluth system occur at a scale of approximately 516 students. By this standard, it can be argued that Duluth's primary education is highly decentralized since only four of Duluth's 24 schools are in this size range.

The second equation (1.2) in Table 1 utilizes a different specification for enrollment. In this equation, enrollment utilization is defined as school enrollment capacity divided by actual enrollment multiplied by 100. If a school had below capacity enrollment, this variable was greater than 100; conversely, if the school was overcrowded, the variable was less than 100. The positive sign of the coefficient indicates, as

Table 1. Two estimated equations for dependent variable (AVC).

Equation	(1.1)	(1.2)
Independent Variable:	Coefficients for (1.1) (t-Values in parentheses)	Coefficients for (1.2) (t-Values in parentheses)
ENR	−1.032	−0.359
	(−2.63)	(−4.00)
ENR^2	0.001	
	(1.55)	
Utilization		1.378
		(1.94)
Trend	68.983	64.633
	(9.65)	(8.77)
Age	1.48	1.604
	(3.50)	(3.72)
Test	−4.54	−7.525
	(−0.29)	(−0.49)
(Constant)	624.25	398.718
r^2	0.59	0.60
F	33.04	33.70

would be expected, that the more the school is below capacity, the higher the per student variable costs. This later specification with the utilization variable is highly significant and it raises the significance of the remaining independent variables in the equation.

Of the remaining variables in (1.1) and (1.2), the trend variable was expected to pick up the effects of time, inflation probably being the most important effect. The sign of the trend variable is positive as would be expected. The age of schools affects per student costs through the increased maintenance and operation expenses of older schools. The positive sign of the age coefficient supports this interpretation. The differences between aptitude test scores (Comprehensive Test of Basic Skills) for the fourth and sixth grades were also included to adjust for quality differences across schools. The scores for the two grades were subtracted, with greater improvement indicated by larger negative values. The negative sign of the coefficient indicates that schools with the most improvement in aptitude scores had lower per student costs. This sign is as expected since this variable picks up a great deal of socio-economic differences across schools. More commonly, variation in school quality is adjusted by including the level of school achievement rather than improvement in the aptitude level. Such a variable, calculated by subtracting the two scores from the national average and summing them, did not explain as much variation in costs as did "improvement in quality" variable.

There are a number of variables that could be applied to any attempt to hold the quality of education constant across schools. Common attempts include the application of such variables as: (a) standardized test scores across schools; (b) the years of education of the faculty for each school; (c) the number of special programs located at a particular school; (d) and student to teacher ratios for each school.

This paper uses the first approach based upon the standardized test scores because of the way resource allocation decisions have been made in the Duluth school system. Past enrollment declines led to layoffs of teachers. Since seniority is a major criterion for determining layoffs, there has been a tendency for relocation of senior teachers to balance the years of education across schools. Further, during periods of declining enrollments and subsequent layoffs, the average age of the teaching staff and their educational attainments has been increasing. Turnover has declined substantially under these circumstances. These events make the second quality adjustment variable, years of education, redundant for the Duluth system. The third variable, the use of special programs, would also be redundant for similar reasons. Dwindling resources have required that special programs be cut back in general and that they be located in the administrative offices, with traveling personnel carrying the programs to all of the schools. It would be impossible to differentiate Duluth schools at the elementary level on the basis of these programs. Finally, the fourth variable, student to teacher ratio, is mandated by law. Teachers in the Duluth system are assigned to schools to maintain this ratio. It would be useless to adjust for differences across various schools on this basis.

The "aptitude improvement" variable was utilized, therefore, since it was available for all schools and for all years used in this study. Without overlooking the problems associated with using standardized tests, this variable does provide a consistent data base for future time series estimations with each new year of the schools' operations added to the existing trend information. It is, therefore, less subject to changing law and/or administrative regulations that are more likely to affect other possible quality attributes of the individual schools. While the use of test scores will adjust the regression equation for socio-economic differences between the schools as well as school quality in general, it should be noted that the coefficient for test scores was not statistically significant. The percent of explained variation (R^2) and the overall F statistic for (1.1) and (1.2) are noted below each equation, respectively.

The second set of equations analyzes the per student cost of land and buildings (AFC). These costs should be affected by number of students: as enrollments drop, the per student share of fixed assets will rise. From a resource management point of view, these assets will be the most difficult to manage in the face of declining enrollments.

Equation 1.3 is shown below. Again, the t values are indicated in parentheses.

$$\underset{}{AFC} = 2{,}905.331 - \underset{(-3.67)}{8.608ENR} + \underset{(3.67)}{7.910ENR_{-2}}$$

$$+ \underset{(1.06)}{10.491UTILIZATION} + \underset{(0.50)}{69.064TREND} + \underset{(1.30)}{6.142AGE} - \underset{(-1.23)}{251.869TEST}$$

The negative sign for enrollments indicates that schools with high enrollments will have lower per student fixed costs. Also highly significant is the enrollment lagged by two years. The positive sign indicates that higher enrollments two years past (i.e., declining enrollments today) are associated with statistically significant increases in cost in the most recent years. The utilization term again has a positive sign, indicating that the more the school is below capacity, the higher the per student fixed costs. The positive sign on age indicates that older schools have somewhat higher per student fixed costs. These latter two coefficients are not statistically significant.

This equation was also adjusted for trend and test scores. The signs are as expected, but neither of the coefficients were statistically significant. The regression explained 26 percent of the variation in per student fixed costs. The overall F was 3.82 and was significant at the 0.003 level.

School Management Decisions

The use of this analysis can best be shown by examining the residuals of costs across Duluth's primary schools. Of primary importance is the actual "variable" costs of the 24 schools. These costs (Table 2, Column 3) have been averaged over the past five years (1975-1980) to minimize the effects from an unusual year or two that may have occurred. Over these past five years, for example, Gnesen, Jefferson, and Irving appear to have the highest AVC, well above the five-year average.

The AVCs for Duluth primary schools are estimated using equation (1.1) on the basis of independent variables, accounting for 59 percent of the variation in AVC between schools. Although Gnesen had the highest actual AVC, on the basis of the independent variables it also had the highest estimated costs (see Table 2, Column 6).

The residual AVC is defined as actual AVC minus estimated AVC. These residuals represent variations in AVC not explained by equation (1.1). These residuals have been interpreted by some as internal inefficiencies (6) in the operation of schools when the residuals are positive (i.e., when Actual AVC > Estimated AVC). Alternatively, where large negative residuals exist (i.e., when Actual AVC < Estimated AVC), internal efficiencies may be present. Significantly, those schools with the highest actual and estimated AVC's have the highest positive residuals. This suggests that these schools are candidates for closer managerial scrutiny where potential reorganization is being considered.

Table 2. Residual Analysis.

(1) Rank	(2) School	(3) Actual AVC	(4) Rank	(5) School	(6) Estimated AVC (Equation 1.2)	(7) Rank	(8) School	(9) Residual AVC (Actual AVC — Estimated AVC)
1	Gnesen	$1,171.55	1	Gnesen	$1,059.06	1	Jefferson	$121.31
2	Jefferson	1,090.99	2	Riverside	1,031.21	2	Gnesen	112.49
3	Irving	1,006.14	3	Emerson	1,001.99	3	Chester Park	60.53
4	Merritt	982.75	4	Jefferson	969.67	4	Irving	52.72
5	Lowell	968.20	5	Merritt	969.17	5	Homecroft	52.08
6	Emerson	946.81	6	Lowell	968.67	6	Cobb	27.03
7	Grant	935.97	7	Nettleton	962.39	7	Lincoln	23.65
8	Kenwood	927.49	8	Irving	953.42	8	Congdon	21.96
9	Riverside	925.72	9	Kenwood	938.54	9	Washburn	14.76
10	Chester Park	915.03	10	Grant	922.10	10	Grant	13.87
11	Cobb	915.00	11	Lakewood	917.00	11	Birchwood	2.23
12	Washburn	909.25	12	Rockridge	913.17	12	Lowell	-.47
13	Congdon	902.37	13	Lester Park	904.47	13	MacArthur	-3.96
14	Nettleton	888.23	14	Lakeside	903.79	14	Piedmont	-5.14
15	Piedmont	884.82	15	Washburn	894.49	15	Kenwood	-11.05
16	Lester Park	884.20	16	Piedmont	889.96	16	Merritt	-13.57
17	Homecroft	874.73	17	Cobb	887.97	17	Lester Park	-20.26
18	Rockridge	869.85	18	Congdon	880.41	18	Rockridge	-43.32
19	Lakewood	863.17	19	Stowe	863.71	19	Lakewood	-53.83
20	Birchwood	856.46	20	Chester Park	854.50	20	Emerson	-55.19
21	Lincoln	833.86	21	Birchwood	854.22	21	Stowe	-62.20
22	Lakeside	822.58	22	Homecroft	822.6463	22	Nettleton	-74.16
23	MacArthur	812.03	23	MacArthur	815.99	23	Lakeside	-81.20
24	Stowe	801.52	24	Lincoln	810.21	24	Riverside	-105.49

Conclusion

The results of this study suggest other possible school management decisions. On the basis of variable costs alone, optimum enrollment for Duluth primary schools was estimated at approximately 516 students. This represents a scale as large as the largest schools in Duluth. The inclusion of fixed costs might suggest perhaps a slightly larger size. When AFC was estimated in a hyperbolic form, the estimation did not yield as good a fit as the linear fit reported in the second equation (1.3).

This study seems to support the view that school consolidations lead to higher costs when enrollments fall, while past studies have supported the view that costs rise when enrollments rise. It appears any changes (either positive or negative) in enrollments lead to higher per student fixed costs.

If school districts move to consolidate, the level of costs (the actual Y values), as well as with any large positive residual values (the difference between the actual and predicted Y values), can be used to decide which schools are candidates for consolidation. Such information is especially valuable when long-term enrollment changes are expected. Clearly, any choices favoring consolidation must be modified in light of quality differences beyond these considered in the economic data for this paper.

A broader implication of the results is found in the notion that public cost functions are capable of measurement, although they are admittedly imperfect. Such measurement is especially crucial in this era of consolidation and related cutbacks in public services. Effective management decisions concerning urban outputs require such attempts, taking us to and beyond traditional cost and benefit notions of public investment toward an increased concern for scale and related efficiencies. Efforts such as this one represent a modest but potentially useful step in that direction.

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References

1. Hirsch, W.Z. 1959. Expenditure implications of metropolitan growth and consolidation. *Review of Economics and Statistics,* XLI: 232-240.
2. Riew, J. 1966. Economies of scale in high school operation. *The Review of Economics and Statistics.*
3. Cohn, E. Economies of scale in Iowa high school operations. *The Journal of Human Resources,* 3(4).
4. White, F. and Tweenten, L. 1973. Optimal school district size emphasizing rural areas. *American Journal of Agricultural Economics.*
5. Hind, I.W. 1977. Estimates of cost functions for primary schools in rural areas. *Australian Journal of Agricultural Economics.*
6. Shepherd, W. 1973. The yields from abating market power. *Industrial Organization Review,* Vol. 1.