Research in Rural Education, Fall 1990, Vol. 7, No. 1, pp. 9-15

Economies of Scale and Rural Schools

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ABSTRACT

The wave or reorganization that changed state systems of common schools from elementary to K-12 organizations during the Twentieth Century is about completed. It was driven by industrialization, mechanization of agriculture, advances in transportation and communications, and depletion of natural resources that changed economic and demographic characteristics of rural areas and resulted in higher educational expectations. Economies of scale arguments were often used and misused to support rural school district consolidation. Additional forces are now affecting rural communities and could generate pressure for another, but less numerically dramatic, wave of reorganization. International markets, decentralized manufacturing, and large scale corporate farming are examples of current trends that are changing rural communities and contributing to increased educational expectations. A second wave of reorganization would again give rise to arguments based on economies of scale. Educational leaders should understand economies of scale, their application to public elementary-secondary education and particular implications for rural schools. Selected references and an overview of the literature from a rural education perspective are presented.

INTRODUCTION

While frequently neglected in other educational research, rural schools and districts have been subjects of research on economies of scale. Economies of scale frequently have been advanced as a rationale for rural school consolidation. Monk and Haller (1986), writing about the lack of balanced presentations of advantages and disadvantages in rural school reorganization, stated:

> There is no reason to expect residents of these villages to be familiar with the arcane literature on economies of scale, for example. There is, on the other hand, every reason to expect school administrators and State officials to be familiar with that literature. It is, or should be, part of their professional knowledge . . . There are two obvious explanations for its absence from these debates. Either the educators and consultants were ignorant of their own profession'sliterature, or they were familiar with it and chose not to mention it (p. 67).

The purposes of the present study were defined by the following questions: What is the concept "economies of scale"? What were the findings of research that examined economies of scale in elementary - secondary education? What significance does educational economies of scale research have for rural school organizations?

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DEFINITION OF ECONOMIES OF SCALE

The economies of scale principle stems from the disciplines of economics and management science. Spencer (1974) defined economies of scale as a curvilinear relationship between average cost and the number of units produced. He identified increased specialization in use of resources, spreading costs over more output units, and the growth of ancillary facilities as sources of economies of scale. The economies of scale principle incorporates its opposite, diseconomies of scale. Spencer cited management overburden as a source of diseconomies of scale. Pratten (1971) drew attention to the complexity involved in application of the economies of scale principle by identifying 14 dimensions of scale, seven sources of scale economies, and four sources of scale diseconomies. He emphasized the importance of 1) including both capital and operating costs in economies of scale studies and 2) the assumption that output quality remains constant at different levels of economies of scale are efficiencies or reductions in average total costs which are associated with increased units of output as described by th long run average cost (LRAC) curve. The LRAC curve, which Pratten preferred to call the scale curve, traces minimal points on short run average cost (SRAC) curves that represent the sum of average fixed and average variable costs at different levels of output. In research on economies of scale in education, the LRAC or scale curve has been found to assume two distinct shapes: 1) a parabolic curve, illustrated in Figure 1, which means that as the level of output increases, average costs decline to a minimal point and then rise to form a parabola or U-shaped scale curve; and 2) a hyperbolic curve, illustrated in Figure 2, where average costs do not increase after the lowest point is reached, so that the scale curve forms a hyperbola or L-shape. Cost is the monetary value of all inputs required to produce the units of output. The lowest point on a scale curve indicates the most efficient or optimum size of the firm or plant.

Application of the economies of scale principle to public education requires definition of the function, nature, inputs, and outputs of school organizations, and of school output capacity. Schools and districts are defined as organizations whose function is to deliver instructional and support services. School organization inputs are the factors of production necessary to generate educational services: personnel, purchased services, supplies, facilities, and equipment. School organization outputs are usefully defined by what Thomas (1971) called the "administrator's production function". Under this definition, each course, co-curricular activity, and support service is treated as an output. The school's output capacity is defined as the maximum number of students who can be offered a specified mix of instructional and support services at given levels of class sizes and staffing ratios. Average costs are measured as the monetary value of the inputs

Figure 1
Scale Curve: Parabolic

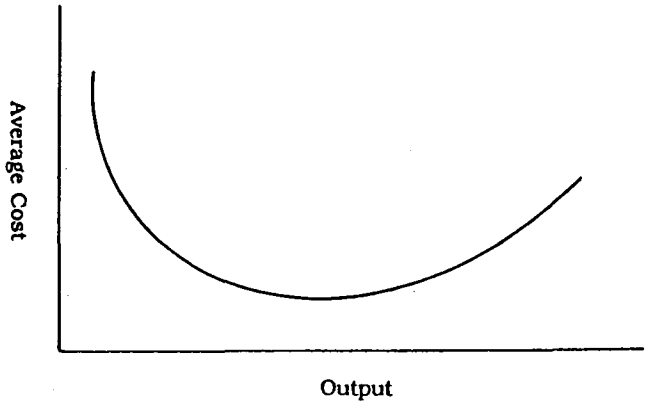
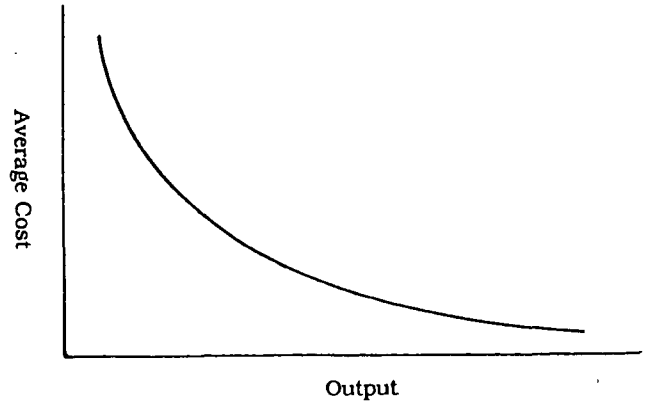


Figure 2
Scale Curve: Hyperbolic



required to offer a particular service divided by the number of service units provided. The total of these average costs for all programs constitutes the average cost of the school or district. Economies of scale are realized for a particular service as long as the addition of one more student results in a lower average cost per instructional contact hour or other unit of service. For a school, economies of scale are realized as long as one service experiences lower average total costs by enrolling one more student. Economies of scale are maximized at the point where the combined average total costs of all services are at their minimum on the school's scale curve.

RESEARCH ON ECONOMIES OF SCALE IN EDUCATION

In 1959, Hirsch published an article on economies of scale in selected local public services. Among these was a study of per-pupil expenditures in 27 St. Louis-area school districts, predominantly of 1500 pupils or more in average daily attendance. Precedent-setting features of the study design included 1) use of cross-sectional data, 2) use of regression analysis to measure average expenditures as a function of average daily attendance and 3) selected inputs serving as controls for the quality of education provided. Pointing out the lack of a single, widely-recognized quality measure, Hirsch used teacher-pupil ratio, percent of graduates entering college, college hours per teacher, teacher experience, teacher salary, and the total number of high school credit units as indicators of educational quality. A sparsity measure, the five-year district growth rate, the percentage of secondary-level students, and district average assessed valuation were used as controlling variables in a least-squares regression analysis to test for scale effects. He found that per-pupil expenditures did not vary significantly with enrollment, and concluded that no economies of scale were operating. Hirsch's work initiated both a redirection and a resurgence in research on the application of economies of scale to elementary-secondary education. The use of cross-sectional data and inferential statistics represented a new methodological direction. Research interest was revived because of previous studies had uniformly found economies of scale.

Following Hirsch's 1959 study, at least 40 studies of economies of scale in elementary-secondary education were reported through 1986. Nine of these studies have been selected to 1) trace development of the research methodology and 2) identify emerging implications for school organizations.

In Cohn's 1968 study of the efficiency and effectiveness of Iowa's secondary schools as they related to attendance, least-squares regression analysis was used to obtain a scale curve comparing average costs across districts. Average daily attendance was used as the school size measure and student scores on the Iowa Test of Educational Development as the quality measure. Cohn's goal was to identify average cost differences per pupil for achievement of the same quality of education. He found that larger schools spent less per pupil for the same quality of education, with an optimal school size for his sample of 1500 pupils. Of more importance for further research was his finding that the assumption of an L-shaped (hyperbolic) scale curve in the estimating equations explained his data better than did the assumption of the conventional U-shaped curve.

In 1971, Sabulao and Hickrod used curvilinear least-squares regression analysis and differential calculus to arrive at an optimally-efficient school district size for Illinois. The authors considered elementary, secondary, and K-12 districts separately. They found 1) an optimal K-12 district size of 8000 pupils in average daily attendance and 2) that K-12 districts were more economical for district sizes of 1500 or more pupils. This conclusion, and the process used to obtain it, may gain significance where a trend in rural areas toward joint high school districts and independent elementary districts develops. Minnesota, for example, is beginning to encourage such combinations. Sabulao and Hickrod contributed to economies of scale methodology by suggesting that the cost functions of large and small schools may be qualitatively different, rendering direct comparisons untenable.

Hambor, Phillips, and Votey's study reported in 1973 broke new methodological ground. First, it used a simultaneous equations approach in regression analysis that eliminated bias in the calculations due to the order of entry of variables into the regression equation. Secondly, it went beyond economies of scale considerations to include the characteristics of the community which the school served. Scale economies in this setting were termed "input elasticities", varying with the unit value per pupil which the community place on educational attainment. Using nationwide data on educational attainment and community characteristics compiled by the U.S. Bureau of the Census, the U.S. Office of Education, and the National Education Association, the authors found only statistically insignificant returns to scale.

White and Tweeten's 1975 study of economies of scale in rural Oklahoma schools contributed to the research methodology by exploring the possibility of differing scale curves in various school cost categories. They stated:

> Trade-offs between internal schooling economies and transportation diseconomies determine the shape of the LRAC curve and hence determine the optimal school district size . . . Past studies gave no consideration to student density, which could affect optimal school district size (p. 45).

They determined the effect of transportation costs on optimal district size by separate regression and analyses on costs in the areas of instruction, administration, operations and maintenance, and buildings and equipment. Eleventh grade composite achievement test scores were used for quality control. Results showed an optimal district size of 800 students with transportation costs excluded and 675 students with transportation included, a 15 percent difference. White and Tweeten found that for their data, U-shaped scale curves characterized all cost categories except operations and maintenance.

Wales' 1973 study of economies of scale in British Columbia school districts further explored the benefits of constructing separate scale curves for school cost categories. Categories analyzed separately were teacher salaries, other instructional, operations, maintenance and repair, and district administration. Using least-squares regression analysis, Wales found econstant returns to scale in all categories except maintenance and repari, and concluded that the assumption of an L-shaped scale curve best fit the case. The teacher salaries category produced another significant finding: large and small schools had differing curves.

Also in 1973. Cohn and Hu published a study of 108 Michigan high schools, undertaken to "illustrate that scale economies by school may be meaningless unless enrollments by program are also considered" (p. 302). Total annual cost per student, pupil-teacher ratio, and average teacher salaries were used as variables in a least-squares multiple regression analysis of 23 high school subject areas. Two sets of equations, one assuming a U-shaped scale curve and one assuming an L-shaped scale curve, were used. Cohn's findings bore out his assumption of differing scale curve shapes among the programs. Where a U-shaped curve was assumed, it was found appropriate for homemaking, office clerk, steno-secretatial, and electricity and electronics. Scale economies, though not a U-shaped curve, were found for agricultural production and mathematics. An inverted U-curve was found for all the non-vocational courses. Here, a region of diseconomies preceded a region of scale economies on the curve. When an L-shaped curve was assumed, only mathematics and homemaking continued to show scale economies, as did several vocational programs which had not exhibited scale economies under the assumption of a U-shaped curve. The findings indicated that assuming a U-shaped scale curve for all programs was not appropriate. Cohn and Hu concluded that the estimation of school economies of scale without regard for program-by-program differences was problematical.

In 1975, Holland and Baritelle published a study of rural schools in a county of Washington State which emphasized the importance of considering unique local conditions in the analysis of the transportation factor in school economies of scale. Pointing out that White and Tweetne's study, summarized above, had assumed one central school, a square road grid, and equal student density, Holland and Baritelle used estimates of building capacity and detailed information on existing school bus routes and student location to calculate the combination of school sizes and locations which would minimize the sum of school and transportation costs. Both short-run and long-run solutions were obtained. Linear programming was used to minimize transportation costs subject to existing student location and school enrollment. Quality of education was assumed to be constant among the schools. Holland and Baritelle found with their improved methodology that maximization of efficiency in transportation resulted in savings of 1.3 percent on school and transportation costs in both the short and long run, and concluded that in this case transportation costs negated most cost savings associated with school district reorganization.

In a 1984 study of economies of scale in British Columbia schools, Coleman and LaRocque added a distinction between district size and school size to the consideration of the benefits of reorganization. Under the assumption that one should "seek causality through longitudinal designs and multiple measures, preferably focusing on outliers" (p.22), the authors investigated the operating costs of the twenty smallest districts in British Columbia, using data from 1972, 1977, and 1982, and supplemented it with interviews of the school superintendents. Seven variables assumed to affect operating costs were examined, first through partial correlations and then through multiple regres-

sion analysis. Coleman and LaRocque found a high correlation between average school size and pupil-teacher ration, and established average school size as more important than district size as a predictor of operating costs. Consolidating districts might conceal but not reduce these costs.

In 1985, Butler and Monk reported a study of New York State districts using 1978-1979 data. They explored Sabulao and Hickrod's suggestion, noted above, that the cost functions of large and small schools are qualitatively different, defined cost differentials in terms of average costs, and proposed that cost differentials among schools and districts of different sizes should be divided into those which were scale effects and those which were not related to scale, e.g., average-cost differences produced by differing teacher salaries. Failing such a division, Butler and Monk assumed, economies of scale may mask existing inefficiencies, and non-scale efficiencies may mask diseconomies of scale. Large and small schools were investigated separately. Translog cost functions were used in order to avoid the assumption of a particular scale curve shape. The functions used separate terms to capture scale-related costs and costs unrelated to scale. Through the use of statistically distinct cost functions for large and small schools (2500 or fewer students), Butler and Monk found that the small schools showed greater economies of scale in that enrollment increases in small districts were associated with smaller cost increases than was the case in large districts. Adding increments of size to small districts, in other words, was less costly than adding the same increments to large districts. The authors concluded that lower levels of efficiency exist in large school districts as compared to small, and that only marginal changes in size needed to be made by small school districts to attain the full measure of scale economies possible. Butler and Monk introduced the concept of "ruralness" to partly explain their results. In this view, the small-town district lowers its cost for student control and public relations because of its close relationship with the community.

IMPLICATIONS FOR RURAL SCHOOLS

Faber's 1966 literature review exemplified the interpretation that efficiencies would result from changing the scale of schools and districts. He found the literature "virtually unanimous in condemning the small district" (p. 34) and advocated districts of 10,000 to 20,000 students. The fact that expenditures almost always continued to rise in consolidated districts was explained (Grieder, 1964) as the overwhelming of efficiencies gained by rising educational expectations in the communities. In writing about optimum school district size in 1969, Hickey reiterated the theme that consolidation was a "means of getting more and better education for tax dollar" through "more efficient administration" and "sound business practices" (p. 7). At the same time, the refinements in economies of scale study methodology cited in the preceding section led researchers to reexamine the implications of economies of scale research for school reorganization. Inclusion of factors such as transportation costs, capital expenditures, student dispersion, quality of education, qualitative differences between large and small schools, community wealth, and program-by-program differences raised growing doubts about the automatic certainty of economies of scale in school reorganization. The retreat from belief in school economies of scale escalated into doubt that they had been proven to exist at all in the case of rural schools and districts. Sher and his associates stated the case against economies of scale as a justification for school reorganization in a collection of studies completed under the sponsorship of the National Institute of Education (NIE, 1977). Two studies in the collection challenged the "myth" that economies of scale resulted from reorganization. Sher and Tompkins faulted research on the subject for unsound methodology and a lack of objective analysis. The alleged that only in cases where there was a compact geographical area and dilapidated existing facilities could any economies of scale be expected. Otherwise, transportation, distribution, higher salary, and new-construction costs would cancel the savings realized from increased purchasing power and from more efficient use of facilities, equipment, and personnel. Sher and Tompkins concluded that economies of scale had been overstated as a benefit of reorganization.

In another component of the NIE project, Rosenfeld studied four Vermont districts of varying sizes and wealth which had consolidated their secondary school operations. On the basis of interviews with the districts' superintendents, Rosenfeld concluded that in this instance economies of scale had not resulted from the unifications. Potential savings through bulk purchasing were cancelled by costs associated with standardization, distribution, and centralization. The larger unified schools were found to have a larger percentage of costs defined as administrative than the

smaller unified schools. Rosenfeld presented no evidence concerning changes in transportation costs or pupil-teacher ratios.

Guthrie and Hind agreed with Sher and Tompkins that economies of scale in the case of rural schools and districts had not been adequately examined, and came to similar conclusions. Guthrie noted that the necessary precision and specificity in performing such an examination had not yet been achieved and concluded that the existing evidence is "exceedingly unclear... Transportation seems to make the difference." (p. 25). Hind noted, in reference to Australian primary schools, that "the small schools remaining are in sparsely populated areas and/or located considerable distances from other schools. The possibility of economies being realized would thus, under present circumstances, appear rather limited." (p. 24). Fox, who in 1981 published a synthesis of 34 studies, concluded that the research in the area of economies of scale in education has failed to produce a model of their operation which was either theoretically sound or beneficial to practitioners.

Is the concept of economies of scale relevant to rural school organizations? At the present time the answer seems to be, "yes, but . . ." The intuitive logic of not establishing a school, a district, or a regional service unit for one student is compelling and raises the persistent question, How many students are needed to justify investment in a school or other type of educational organization? Decisions about the proper scale of school organizations are needed and must be made in thousands of rural communities. Since 1960, the long-standing assumption that economies of scale inevitably result from rural school consolidation has been frequently challenged. Useful and important insights into the complexity of economies of scale as they relate to schools and districts have been gained, but at the expense of certainty. The fact that adequate research models for application of the economies of scale principle to school organizations are lacking has not, however, invalidated the concept, or reduced its importance in school reorganization. Consolidation plans continue to be sold to communities ont ehbasis of lower costs or "more education for the tax dollar", both of which are economies of scale arguments. If arguments based on the economies of scale principle are used, it is important that their estimation be accurate, and not mask or reduce consideration of other reasons for restructuring school organizations such as

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