Revisiting Economies of Size in American Education: Are We Any Closer to a Consensus?

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Abstract

Consolidation remains a common policy recommendation of state governments looking to improve efficiency, especially in rural school districts. However, state policies encouraging consolidation have increasingly been challenged as fostering learning environments that hurt student performance. Does the empirical research on economies of size support for this policy? The objective of this paper is to define the factors affecting economies of size and update the literature since 1980. The best of the cost function studies suggest that sizeable potential cost savings in instructional and administrative costs may exist by moving from a very small district (500 or fewer pupils) to a district with approximately 2,000 to 4,000 pupils. The findings from production function studies of schools are less consistent, but there is some evidence that moderately sized elementary schools (300 to 500 students) and high schools (600 to 900 students) may optimally balance economies of size with the potential negative effects of large schools. Since program evaluation research on school consolidation is limited, it is time for researchers on both sides of this debate to make good evaluation research on consolidation a high priority. In addition, the potential diseconomies of size in large central city school districts needs increased attention in academic research.

JEL Classification: H7, I2

Key words: costs, economies of scale, efficiency

1. Introduction

School district consolidation continues to be an important and controversial issue facing public schools in many states. While the pace of school district consolidation has slowed considerably since the early 1970s, states still provide incentives for district (or school) consolidation through separate aid programs and generous building and transportation aid (Gold et al., 1995). Many state governments provide mixed incentives to their school districts with regard to scale. Close to one-half of the states adjust their operating aid formulas for sparsity or small scale, and in some cases the adjustment is sizeable (Gold et al., 1995). Some states also provide financial assistance to small charter schools and support other innovations in school organization that emphasize smaller schools.

As state governments continue to raise student performance standards and take over an increasing share of the financing of education, pressure will mount on local school officials for both improved productive efficiency and student performance. School and district reorganization are likely to remain on the agenda. The principal question posed by this paper is whether after three decades of empirical research on education production and costs are we any closer to a consensus on the effects of size on costs and student performance? A cursory review of the literature suggests that no consensus exists. The early evidence on economies of size in schools and districts, summarized by Fox (1981), indicates that the cost-minimizing size for urban high schools was generally above 1,000 pupils, and for districts as large 30,000 pupils. Smaller minimum cost points were found for rural schools, but economies of size existed over some range of enrollment. In contrast, more recent research on student performance in schools indicates that small may be beautiful. “All else held equal, small schools have evident advantages for achievement, at least among disadvantaged students” (Howley, 1996, p. 1).

Fox (1981) also found inconsistent results across the studies he examined, which he attributed in part to a lack of a “theoretical base” (p. 273). Instead of being based on a structural model of local government behavior, many of these studies utilized ad hoc expenditure or student achievement models. Fox raised a number of important conceptual and empirical issues that should be addressed in research on economies of size. The objective of this paper is to examine the literature on scale economies in education since Fox to determine whether the quality of the empirical models and measures has significantly improved, and if so, whether this has lead to more consistency in the empirical results. The remainder of the paper is organized into three sections. We begin with a brief presentation of conceptual models of education production and costs and then use these models to discuss factors affecting economies of size in education. The main part of the paper is a review of the literature on economies of size in education since 1980.

We conclude with our principal findings and recommendations for future research. While it is premature to claim that there is a convergence of empirical research, especially among production function studies, some common findings exist that are suggestive of what may emerge in future research. Cost function results indicate potentially sizeable cost savings up to district enrollment levels between 2,000 and 4,000 students, and that sizeable diseconomies of size may begin to emerge for districts above 15,000 students. At the school level, production function studies provide some evidence that moderately sized elementary schools (300 to 500 students) and high schools (600 to 900 students) may optimally balance economies of size with the negative effects of large schools.

2. Education production, costs and economies of scale

Before analyzing economies of scale in education, it is important to develop a general conceptual framework. Without a theoretical foundation to guide model specification, it is easy to omit important factors, which could lead to biased results. As Fox (1981) pointed out, education research is littered with ad hoc expenditure and student achievement models from which it is difficult to draw meaningful conclusions. In this section, we will briefly present standard models of education production and costs, and use them to carefully define economies of scale in education.

2.1 Production and cost models

The provision of public education is a complex process involving many actors and types of resources. Despite this complexity, education researchers often employ simple production function concepts to model the input and output decisions of schools and school districts. The school district acquires and employs various school inputs (represented by the vector X) to produce a range of educational activities (G), which represent direct services provided by schools, such as lessons, counseling sessions or bus trips; $G = f(X)$.

Given that the direct services of schools are difficult to measure, most education production functions use outcome or performance measures, such as achievement test scores or drop-out rates, as the dependent variable. Although they are controversial, performance measures are generally available, and do better capture what parents and voters in a school district ultimately care about. As is well recognized, student achievement (S) is a function not only of school activities (G) produced from purchased inputs (X), but also of student, family and neighborhood characteristics (E), physical factors, such as the enrollment size of the school and district (N), and other unobservable district or school specific effects (δ), such as productive efficiency. The standard production function for student performance can be represented as;[1]

$$S_t = h(G, E, N, \delta) \text{ or } h(f(X), E, N, \delta). \quad (1)$$

In practice, most studies have used simple linear or log-linear production functions at either the school or district level, with outcomes and inputs generally measured in per pupil terms. Education production functions at the school or classroom level provide greater visibility on how classroom and especially teacher resources affect student achievement (Ferguson & Ladd, 1996). However, it may be difficult to fully capture economies of size at the district level using school or classroom level data, because of the difficulty of assigning indirect costs, such as support staff and administration, to individual classrooms. Production functions in general require accurate estimates of the quantity and quality of inputs. While counts of teachers, support staff, and classrooms (or specialized facilities, such as labs) are available in many states, good quality measures for inputs are relatively rare.[2]

Partially in response to some of these difficulties, many researchers have employed cost functions as an alternative method for estimating returns to scale. As applied to local schools, the term "costs" refers to the minimum amount of expenditure or outlay needed to produce a given level of student achievement, which implies no technical inefficiency. In practice, researchers have used actual expenditures, because they are readily available. Thus, it is important in cost function estimation, as with production functions, to control for unobserved factors, such as inefficiency.

In addition to controlling for efficiency, it is important to recognize when estimating a cost model that public production is part of a behavioral system, that includes a demand equation. Thus, service outcomes and expenditures are determined simultaneously and should be treated as endogenous. Utilizing the production framework that was discussed previously, the standard private sector cost function can be modified to reflect the determinants of education spending. An education cost model can be found by solving equation (1) for G and substituting into a standard cost function,

$$EX = c\left(h^{-1}(S,\ E,\ N,\ \delta)W\right) = c'(S,\ E,\ N,\ \delta,\ W). \qquad (2)$$

where *W* represents teacher salaries. Equation (2) provides a flexible form for bringing educational outcomes, student population, environmental variables, and factor prices into an analysis of public production. Expenditures are usually expressed in per pupil terms, and teacher salaries are the most common factor price used in these models. By controlling for differences across districts in student achievement, environmental factors, factor prices, and efficiency, this expenditure model should yield more accurate estimates of economies of size than an ad hoc or incomplete expenditure functions.

2.2 Defining economies of size

In standard production theory, returns to scale is defined as the percent change in output resulting from a 1 percent increase in all inputs. Assuming factor prices are independent of scale, then economies of scale, which measures the relationship between average costs and output, and returns to scale are equivalent. In public production, in fact, three different measures of scale are relevant to education production: activities (*G*), student outcomes (*S*), and school or district size (*N*). Given proper specification of this equation, it would be possible to estimate measures of returns to scale with regard to all three dimensions (Duncombe & Yinger, 1993). The traditional concept of returns to scale in the private sector, which has been called technical returns to scale, can be represented by the elasticity, $(dG / DX)(X / G)$, or for technical economies of scale, $(dTC / dG)(G / TC)$. If a 1 percent increase in inputs (*X*) leads to a greater than 1 percent increase in output (*G*), then the organization is enjoying increasing technical returns to scale (or equivalently economies of scale).

The type of returns to scale that is the focus on this paper is returns to size (or enrollment), which can be represented by the elasticity, $(dS / dN)(N / S)$. Economies of size can be defined formally as the elasticity between per pupil expenditures (*EX/N*) and enrollment *N*, controlling for student achievement, *S*, and socio-economic cost factors, *E*. Using the expenditure function (2) this elasticity can be expressed as (Duncombe & Yinger, 1993);

$$\frac{\partial\left(\frac{EX}{N}\right)}{\partial N}\frac{N}{\frac{EX}{N}}=\left(\frac{\partial EX}{\partial G}\frac{G}{EX}\right)\left(\frac{\partial G}{\partial N}\frac{N}{G}\right)-1=\theta_1\,\theta_2-1. \quad (3)$$

Economies (diseconomies) of size exist if this expression is less than (greater than) zero. Economies of size imply that per pupil expenditures can be reduced by expanding the student population, i.e., consolidation may reduce per pupil expenditures. Equation (3) permits decomposition of economies of size into two separate elasticities .

The first elasticity, θ_1, is **technical economies of scale** representing the relationship between costs and the quantity of school activities, and is the parallel cost concept to technical returns to scale. Defining the output of schools as lessons, technical economies of scale would exist if the cost per lesson decreased as the number of lessons provided by a school increased, or equivalently a 1 percent increase in school inputs leads to a more than 1 percent increase in lessons of constant quality. Most activities performed in the production of education are labor intensive so that an increase in lessons would require a proportionate increase in teacher time, suggesting that constant technical returns to scale may be the norm in education. One possible source of technical economies of scale is the price benefits of larger size, since large districts may be able to negotiate bulk purchases of supplies and equipment. However, Tholkes (1991) argues that there are price disadvantages to getting larger as teacher unions are more apt to organize larger districts, and wages are typically “leveled up” to those of the most generous district. In addition, these economies could be offset by higher transportation costs. Consolidating districts generally pool children in similar grades together in the same building, which usually results in longer average commute times.

Besides adding to the operating costs of transportation, Kenny (1982) has pointed out the potentially significant opportunity costs to students and parents of longer travel time to school.

The other elasticity, θ_2, measures the degree of **congestion or indivisibility** that exists for school resources, and is expected to be greater than or equal to zero. Tholkes (1991) cites the advantages of a large school district being able to efficiently utilize specialized labor, such as math and science teachers, and specialized facilities, such as science and computer labs. Administrative costs may also reflect this type of decreasing costs since central administrative staff and support personnel, such as counselors, presumably can be shared among a number of students, so that higher enrollments should be associated with lower per pupil administrative costs.

Offsetting the cost benefits of larger enrollments in schools or districts is the potential of **lower student and staff motivation and parental involvement** in larger schools. It has been argued that students in smaller schools have a greater sense of belonging to the school community, and school personnel are more apt to know students by name, and to identify and assist students at risk of dropping out (Cotton, 1996; Barker & Gump, 1964). Many of the recent critics of large schools have argued that administrators and teachers may have a more positive attitude toward work in small schools, because there is less formalization of rules and procedures, and it is easier to be flexible in a small school (Cotton, 1996). In addition, parents may be more apt to participate actively in a school where their contributions will have a tangible effect, and where the school administration is willing to be more flexible. Higher parental involvement can help improve school decision making, as well as influence student and teacher motivation.[3]

3. Research on economies of size since 1980

Fox (1981) provided a detailed review of the literature on economies of size before 1980. The principal objective of this paper is to update his literature review, and evaluate the methodology and results of these papers using the theoretical framework provided in the last section. While our review is not comprehensive, it does include most of the cost and production function studies since 1980 that incorporate enrollment as an independent variable.

3.1 Cost function studies

Expenditure functions have been the traditional model used to estimate economies of size. Per pupil expenditures are regressed on a set of resource prices and non-school inputs, including the number of pupils. The square of enrollment is also commonly included to allow for a U-shaped cost function, and estimates are provided of the minimum cost enrollment level. Building on the key issues raised by Fox (1981), we have evaluated each study on several methodological criteria;

1. What level—school or district—is the unit of analysis, and what measures of size are used?
2. What outcome variables are included in the cost model, and do they cover a range of subjects and measures of the performance distribution?
3. Is the cost function estimated as part of a local behavioral model in which expenditures and outcomes are set simultaneously? In other words, is any attempt made to control for the influence of demand on expenditures and outcomes?
4. What factor prices are included in the model, and is there any attempt to adjust staff salary estimates for differences in quality?
5. Are any attempts made to correct for omitted variables, such as bureaucratic inefficiency?
6. What functional form is used to estimate the cost function? What happens to economies of size estimates when more flexible functional forms are used?

We begin our literature review with an evaluation of how well the ten cost studies reviewed for this paper have addressed these methodological issues, before turning to the economies of size results.[4]

3.1.1 Methodological review

With the exception of Deller and Rudnicki (1992), all of the cost studies we reviewed are at the school district level and, except for Duncombe, Miner, & Ruggiero (1995), do not include enrollment size for individual schools. For most states school level expenditure data are not available.[5] Enrollment is the principal measure of size, although a few studies use average daily attendance (ADA) instead. Expenditure data is generally either total expenditures or operating expenditures. Only one study, Duncombe, Miner and Ruggiero (1995) examined economies of size for transportation costs and administration.

All of the studies analyzed included some measure of student outcomes as well as enrollment.[6] Average test scores are the most common measure of student performance, particularly in math and reading (Table 1). In general, these studies do not provide any justification for their use of the average score compared to measures of other part of the performance distribution.[7] Several studies have included test scores for multiple grade levels, but no study has taken the difference in test scores across multiple years as the measure of gains in student achievement. The lack of use of gain scores is understandable, given that most states uses comprehensive tests in only a few grades, and these tests are seldom comparable across grades. A few studies use graduation measures, dropout rates or special diplomas, in addition to test scores.

< Table 1 about here >

Only recently have researchers followed the recommendation of Fox (1981) by modeling costs as part of a behavioral system involving the demand for education. Two approaches are available to account for the influence of voter demand on expenditures and outcomes. A reduced-form expenditure function results from the substitution of the demand equation into the cost equation for outcomes; two studies have taken this approach (Ratcliffe, Riddle, & Yinger, 1990; Downes & Pogue, 1994). While the use of the reduced-form approach avoids the necessity for outcome measures, it raises the possibility of measurement error since outcomes are measured indirectly using demand factors. Four studies have adopted a more direct approach which involves treating outcomes as endogenous and use exogenous demand variables as instruments (Downes & Pogue, 1994; Duncombe, Ruggiero, & Yinger, 1996; Reschovsky & Imazeki, 1997, 1999).[8]

With the exception Ratcliffe, Riddle, and Yinger (1990), the empirical cost functions have included factor prices, particularly teacher salaries.[9] Variation in average teacher salaries may reflect differences in the level of human capital that teachers have accumulated, and reflect differences in the market wage that would have to be paid to recruit teachers, because of differences in cost of living and working conditions across school districts. To capture the underlying market wage, studies should make some adjustments to salaries for teacher experience and education; five studies have made such adjustments.[10] Other factor prices included in cost functions include other staff salaries (three studies), annual rental price of capital (one study), and expenditures for capital and administration (two studies). Expenditures, by mixing input quantity and price, are not very accurate measures of factor prices. For inputs, such as capital, where factor prices are not likely to vary significantly across districts, expenditures are primarily measuring variation in input quantity.

Socio-economic factors representing the education environment are a standard feature of all studies we examined. Common factors in the models include race and ethnicity, income or poverty, adult education, special needs, limited English proficiency, and the percent of secondary students in the district. The four most recent studies, which focus on developing education cost indices, pay particular attention to the specification of these factors. Even in these studies, the variables represent district-level aggregates, which may provide only rough proxies for the neighborhood and family environments faced by disadvantaged students if there are significant differences between district schools in their socio-economic environment.

All studies, except three, use a simple linear or log-linear functional form for the cost model. Butler and Monk (1985), Callan and Santerre (1990), and Gyimah-Brempong and Gyapong (1991) estimate translog cost functions, which add flexibility by including a number of interaction terms.

In the context of this paper, interactions between enrollment and socio-economic factors are potentially interesting, because they might indicate whether the effects of enrollment on spending depends on the socio-economic environment. None of these studies find these interactions to be statistically significant.

The last methodological issue we will address is whether the cost studies have made some correction for inefficiency or other potential omitted variables. Five different approaches for controlling for inefficiency have been employed. Ratcliffe, Riddle, and Yinger (1990) included measures of private school students which could serve as a rough proxy for competition for the public schools.[11] Two studies have employed stochastic frontier regression methods (Deller and Rudnicki, 1992; Duncombe, Miner, and Ruggiero, 1995) to take efficiency into account in the estimation of the cost function. They generally did not find large differences between the results of the frontier regression and OLS regression with regard to the enrollment variables. Downes and Pogue (1994) employ panel data methods to control for district specific effects. Duncombe, Ruggiero, and Yinger (1996) include in their cost model an efficiency index produced using a linear programming approach, called DEA. They view the DEA measure as serving a similar role to a fixed-effects model, by capturing the effects of omitted variables including efficiency. Finally, Butler and Monk (1985) have attempted to decompose scale versus bureaucratic efficiency effects by comparing coefficients in a cost model for large districts with those for small districts. The difference between the coefficients on enrollment, teacher salaries, and other cost variables, is interpreted as an estimate of efficiency differences.

3.1.2 Review of economies of size results

While no study has addressed all of the methodological issues raised by Fox (1981), significant improvements have been made in the quality of the cost function studies, especially since 1990. Have these improvement translated into consistent estimates of economies of size? Despite the variety of measures used, a surprising level of consistency in the results exists among these 12 studies (Table 2). With the exception of two studies, all these studies have found some degree of economies of size. Butler and Monk (1985) found constant returns to size for large districts (average of 4,800 students), but economies of size for small districts (average of 1,100 students). Deller and Rudnicki (1992) found a U-shaped relationship using OLS, but no relationship between costs and size when a frontier regression method was used.

< Table 2 about here >

District level studies can be divided into three groups based on the specification of the enrollment variable. Three studies specify enrollment in either a linear or log-linear form. Two of the studies (Ratcliffe, Riddle, & Yinger, 1990; Downes & Pogue, 1994) find statistically significant economies of size. Downes and Pogue (1994), for example, find using data for Arizona that a 1 percent increase in enrollment is associated with a 0.18 percent decline in per pupil operating and maintenance costs using a fixed-effects model, but only a 0.09 percent decline with a random-effects model. Two of the district level studies have estimated the more general translog cost function. At the mean value for all variables, both Gyimah-Brempong and Gyapong (1991) and Callan and Santerre (1990) find economies of size.[12] The translog function is more flexible, but the specific studies using this model have addressed fewer of the methodological issued discussed above.[13]

A third group of studies includes estimates from a log-linear cost function with the log of enrollment and it square to capture a U-shaped per pupil cost curve. These four studies (Duncombe, Miner, & Ruggiero, 1995; Duncombe, Ruggiero, & Yinger, 1996; Reschovsky & Imazeki, 1997, 1999) have been since 1994 and address most of the methodological issues raised by Fox (1981). As expected, a U-shaped cost curve is found for most types of expenditures. For total costs, the cost-minimizing district enrollment is approximately 6,000 students, for operating or instructional costs the optimal is in the 2,000 to 3,500 range, and for transportation costs the optimal enrollment is just over 1,000. In contrast, economies of size for administrative costs were estimated to exist over all ranges of enrollment in their sample. Even for total costs, Duncombe, Miner, and Ruggiero (1995) found that 90 percent of the cost savings were exhausted by the time the district reached 1,500 pupils. For New York State, they found that one-half of the cost decrease was due to declining per pupil administrative costs, which dropped from $1,124 per pupil with 50 pupils to $193 per pupil with a size of 1,500.

None of these studies have taken into account the increase in opportunity costs for travel time for parents and students when several districts consolidate (Kenny, 1982). In sparsely populated districts, the increase in travel time resulting from consolidation of high schools in two neighboring districts, for example, may make consolidation infeasible. Without reduction in buildings and staff, consolidation is unlikely to save very much money (Duncombe, Miner, & Ruggiero, 1995).

3.2 Production function studies

The second approach used for estimating economies of size has been through the use of student achievement production functions. A voluminous literature on education production functions has accumulated over the last 30 years, and has been thoroughly reviewed in Hanushek (1986), Hedges, Laine, and Greenwald (1994), and Verstegen and King (1998). The focus of most of these studies has been on two questions: does money matter, and what is the role of family and peers on student performance? School or district size, when it has been included in this research, has often been a secondary control variable. Of the numerous production function studies since 1980 cited in the literature reviews, we found only seven that included size as a determinant.[14] We included these seven papers in our review.

While size has not been a major issue in most production function research, a smaller group of studies have used the production function approach to explicitly examine the influence of size on student performance. These studies appear motivated, in part, by early research that pointed to the advantages to being small (Barker and Gump, 1964; Sher, 1977). While the number of studies in this category are still relatively small compared to the total production function literature, the results are supposedly conclusive enough that some researchers are claiming,

> Research on the affective and social effects of school size is extensive and highly consistent in its findings. Thus, assertions about these effects are offered with a high degree of confidence. (Cotton, 1996, p. 1)

Of the studies focusing directly on the enrollment-performance relationship, five were deemed methodologically strong enough to warrant review in this paper.[15]

The objective of this section is to examine these 12 production function studies to determine whether we have reached a consensus on the effects of size on student achievement. Using the following criteria, we will review the methodology used in these studies, before turning to the results related to returns to scale.

1. The level of analysis is equally important for production function studies. The use of student or classroom data is the ideal, supplemented with information on the school and district (Hanushek, Rivkin, & Taylor, 1995; Ferguson & Ladd, 1996) However, if different levels of aggregation are going to be examined in the same study, then suitable estimation methods should be used, such as hierarchical linear models (Bryk & Raudenbush, 1992).

2. What is the functional form of the model, and the enrollment variable? Are more general forms of production functions used that allow for a non-linear relationship with enrollment, and interactions with SES variables?

3. A range of outcome measures should be examined, since no one outcome measure adequately captures all dimensions of student performance. Value-added approaches should be employed to control for cumulative effects of education.

4. A comprehensive set of inputs should be included in the model, ideally including both input quantity and quality measures. Of particular importance, are measures of teacher quality, including experience, education, and performance on achievement tests.

5. Are any attempts made to correct for school-level effects, such as bureaucratic inefficiency?

3.2.1. Methodological review

In terms of the unit of analysis, 4 of 12 studies are at the district level, four have school level data only, and four include both student, and school level data (Table 3). Of the five articles with student level data, only the two most recent papers (Ferguson & Ladd, 1996; Lee & Smith, 1997) use a methodology that explicitly accounts for the different levels of aggregation (hierarchical linear models).[16]

The functional form of most of these models is a simple linear production function, which appears to be used primarily for simplicity (Table 3). It is puzzling that functional form has been an important issue addressed in the cost literature, but the same attention has not been paid to the functional form of education production function. Moreover, the enrollment variable is also put in the model in linear form, instead of the quadratic specification common with cost functions. The assumption of a constant absolute decline or increase in test scores with a one pupil change in enrollment is unrealistic at all enrollment levels. Exceptions include Baum (1986) and Kenny (1982) who both use log-linear functions for all variables, and Lee and Smith (1997) who use a spline function for enrollment. Three studies have included interactions between enrollment and other variables, including race (Summers & Wolfe, 1977), student SES and race (Lee & Smith, 1997), and all the variables in the production function (Eberts, Kehoe, and Stone, 1984).[17]

< Table 3 about here >

Most studies use a variety of outcome measures as the dependent variables in their production functions. Average achievement test scores remain the typical measure, but studies have included the percent of student achieving basic competency, and dropout rates. Despite the emphasis that has been placed on value-added measures in education research, less than one-half of the studies attempted to control for cumulative effects. Felter (1989) includes achievement measures for the same year as controls in their analysis of dropout rates, which raises concerns about the endogeneity of these measures. Sebold and Dato (1981) use a synthetic cohort by including as a control the test scores for first graders in the same year as the test scores for other grades used as dependent variables. One of the advantages of student-level records is that it may allow the use of true value added controls, either by including a previous test score in the regression (Ferguson & Ladd, 1996), or using the change in test scores as the dependent variable (Summers & Wolf, 1977; Lee & Smith, 1997). Three studies include some form of efficiency correction, either in the form of a private school variable (Ferguson & Ladd, 1996; Lee & Smith, 1997), or by using a frontier regression method (Deller & Rudnicki, 1993).

As a production function, we would expect school and non-school inputs to represent the principal variables in the model. Ideally, school inputs would capture both the quantity and quality of inputs. Class size or pupil-teacher ratios are the most common school input used in production functions, and they appear in one-half of the studies reviewed. Decades of production function research has indicated that teacher quality measures are of particular importance to student performance (Hanushek, 1986; Ferguson & Ladd, 1996). Seven of the twelve studies include at least one variable in the model measuring teacher experience, education, test score performance, or quality of undergraduate institution. Most of the remainder of the studies use expenditures as their school input. Expenditures represent a proxy measure of teacher inputs if there are not significant factor price differences across school districts. This assumption may be reasonable in a relatively homogenous state, but in states with large urban areas labor prices are likely to vary significantly between urban and rural areas. One study (Lee & Smith, 1997) surprisingly does not appear to include any school input measures in their models, which implies that the coefficients on the enrollment variables may be biased.

3.2.2. Review of returns to size results

While more uneven in quality, significant methodological improvements have been made in production functions, particularly in the use of student-level data matched with school and district variables. Unfortunately, less attention has been paid to the functional form of the production function, and, in particular, the form of the enrollment variable. It is fair to say, that many of the strongest production function studies have not focused on the relationship between enrollment and student performance.

We will divide our discussion of production function results into those studies that estimate returns to size for schools and those that estimate returns to size for districts (Table 4). It is possible in school level studies to estimate the returns to scale for both school and district. Among the studies we reviewed, only Ferguson (1991) estimated both. Ladd and Ferguson (1996) estimated a school-level production function, but included district rather than school enrollment in the model.

< Table 4 about here >

Five of the studies reviewed estimate returns to size at the district level. District-level studies provide mixed results on economies of size (Table 4). Walberg and Fowler (1987) and Ferguson (1991) find decreasing returns to size, i.e., larger districts are associated with lower student performance. Sebold and Dato (1981) and Baum (1986) find either constant returns to size (statistically insignificant coefficients on the enrollment variable), or increasing returns to size. Ladd and Ferguson (1996), in methodologically one of the strongest production function studies we reviewed, find clear evidence of increasing returns to size for Alabama school districts. Given the wide variation in specifications between these studies, and given that none of these studies used a quadratic specification for the enrollment variable, it is difficult to identify the reasons for the inconsistent results.

In general, the estimates of school-level returns to size are much more consistent. The three studies of elementary schools found either constant returns to scale or decreasing returns to scale. The results from Eberts, Kehoe, and Stone (184) suggest that moving from a small (under 200 students) to a medium (400 to 600 students) elementary school has little impact on student performance, but that performance deteriorated significantly once the school exceeded 800 students. Summers and Wolfe (1977) found that white students were not adversely affected by large elementary schools in Philadelphia (average 917 students). However, blacks were much more apt to experience decreasing test score performance moving from a small to large school. Using district level data, Ferguson (1991) estimated a negative enrollment-performance relationship even for moderately sized elementary schools (average enrollment of 563).

At the high school level, only Kenny (1982) estimated increasing returns to size for high schools. Fowler and Walberg (1991) found either constant returns to scale or decreasing returns to scale for secondary schools in New Jersey. The average school in their sample was of moderate to large size for high schools (1,070 students). In contrast, the average high school in the samples used by Ferguson (1991) and Felter (1989) was approximately 1,500 students, and both studies estimated a negative relationship between enrollment and student outcomes.

Lee and Smith (1997) provide one of the most direct estimates of the impact of size on student performance. Using a panel study of high school students, they examined the determinants of changes in test scores between 8th and 12th grades. Besides controlling for various student related factors (at the student level) and other factors (at the school level), they concentrated their attention on the impacts of size on the performance of students of different SES and race. Surprisingly, Lee and Smith (1997) do not include school inputs in the production function, which implies that their results could be seriously biased. To provide a more detailed analysis of size, they include a series of dummy variables representing different size classes, and then interact these dummies with student

SES and race. The results of their study are surprisingly consistent; the optimal size for a high school is between 600 and 900 students, even when a student's socio-economic background is taken into account. The performance of low SES students falls much faster than high SES students when the high school is larger than 1,000 students. They conclude that many of the present high schools are probably too large, but that recent reforms to promote smaller schools may lead to high schools that can be too small. While their study provides a good foundation for future production function research on returns to size, the lack of school input data limits any general conclusions that can be drawn from their results.

4. Conclusions

Consolidation remains a common policy recommendation of state governments looking to improve efficiency, especially in rural school districts. Does the three decades of research on economies of size provide empirical support for this policy reform, and under what circumstances? The objective of this paper has been to update the literature on economies of size since Fox (1981), and to ascertain whether we are any closer to a consensus on this question. We have paid special attention to methodologies and models employed by these studies to assess whether they have addressed the issues raised by Fox (1981). In general, the quality of both cost and production studies has improved significantly since 1980.

Returning to the question put forth in the title to this paper, can we draw any consensus about economies of size based on education cost function research? A first pass through the results suggests that there still appears to be significant variation in the results of the cost studies of school districts. On closer inspection, these studies provide a more consistent story on economies of size than found in Fox (1981). Sizeable potential cost savings may exist by moving from a very small district (500 or less pupils) to a district with approximately 2,000 to 4,000 pupils, both in instructional and administrative costs. Per pupil costs may continue to decline slightly until an enrollment of roughly 6,000, when diseconomies of scale start to set in. One clear distinction between the recent estimates of economies of size compared to those reviewed in Fox (1981) is that they show the cost-minimizing district size to be at a much lower enrollment.

Given that these cost function studies do not take into account the opportunity costs of increased travel time for students and parents (Kenny, 1982), the optimal enrollment, especially in sparsely populated districts, is likely to be at significantly lower levels. A key first step for any districts considering consolidation is to determine the total travel times for students and parents that is likely to result from consolidation of schools across the districts. If these travel times (and the implicit opportunity costs) are too high, then any cost savings that will result from consolidation will have to arise from reduction of administrative expenditures and support staff and services, not from savings in teacher salaries or maintenance and capital costs from the consolidation of school buildings. Duncombe, Miner, and Ruggiero (1995) found in New York, for example, relatively few rural districts that were good candidates for full consolidation.

While significant methodological improvement have been made in production function research, the strongest production function studies have not focused on size as a key determinant. Mixed results emerge from those studies estimating returns to size at the district level. The results from estimates of returns to size at the school-level are more consistent. Generally, larger schools are associated with lower student performance holding school and nonschool inputs constant. However, these studies have not allowed for a nonlinear relationship between enrollment and student performance, thus, we can’t determine whether decreasing returns to size exist only for schools above a certain size. Based on average enrollment in schools in these production function studies, decreasing returns to size may begin to emerge for high schools above 1,000 students and elementary schools above 600 students. Lee and Smith (1997), who estimated a spline function for enrollment, found that the high school size maximizing student performance gains is between 600 and 900 pupils for both high and low SES students. However, the lack of student input data in their production function limits any general conclusions that can be drawn from their study. The study by Eberts, Kehoe, and Stone (1984) suggests that moderately sized elementary schools (300 to 500 students) may also be the appropriate size.

Is it possible to reconcile the results from the school-level production function studies with cost function studies of school districts? While none of the empirical studies we examined explicitly focuses on the optimal district and school size combination, some tentative conclusions can be drawn from existing research. The basic story seems to be that moderation in district and school size may provide the most efficient combination. Under some conditions, consolidation of very small rural districts may save money, as long as schools are kept a moderate size, and transportation times remain reasonable. The typical suburban or small city district between 4,000 to 8,000 students may have an appropriate size, but the use of a single high school between 1,500 to 3,000 students might be too large, especially if there are a significant number of disadvantaged students. Few of the empirical studies focused explicitly on large central city districts, but extrapolating from existing results indicates that most central cities are operating at enrollment levels with significant diseconomies of scale both at the district and school level. Future research on economies of size needs to refocus on large city districts, and examine whether use of smaller schools can compensate for the large size of these districts.

A logical question to ask after 30 years of research on economies of size is, “where do we go from here?” Should emphasis still be put on refining production and cost functions in the hopes that they will provide a consistent conclusion on economies of size and consolidation? Certainly, improvements in the production and cost models and estimation methods are valuable. In cost research, there is a need to combine more flexible functional forms, such as the translog model, with better controls for efficiency and the endogeneity of outcomes. The use of more flexible cost functions will permit estimates of the interactions between enrollment and socio-economic variables. The recent improvement in production function methodology should be applied to a more flexible specification of enrollment variables in production functions, which allows for interactions between size, and school and nonschool inputs. Such interactions in cost and production functions will reveal whether enrollment has a differential effect on students from different backgrounds. Despite its limitations, Lee and Smith (1997) provides a step in the right direction.

While cross-sectional regressions can be suggestive of potential economies of size, ultimately, consolidation is a policy change that should be evaluated using longitudinal methods. Carefully crafted evaluations of school and district consolidations is required to ascertain the actual impacts of consolidation on expenditures and student performance. Such evaluations would shift the focus of research from speculation about how the cost-size relationship could play out in consolidated schools to an examination of consolidation experiences themselves. These evaluations should be built on a solid research design, which includes significant pre and post-consolidation data for both the consolidating districts, and a similar control group (Cook and Campbell, 1979). Appropriate statistical methods would be employed to rule out unobserved school or district effects, and sample-selection issues. In our brief review of the evaluation literature on school district consolidation, we found no evaluations that fit these criteria.[18]

In short, despite massive consolidations of school districts in the United States, there is little convincing evidence on how consolidation actually affects school districts in the long-run. Both the claims of supporters of consolidation, including many state education departments, which have been strongly “encouraging” rural district consolidation, and detractors that claim small is beautiful, have not adequately been tested using good evaluation methods. It is time for researchers on both sides of this debate to make good evaluation research on consolidation a high priority. This research will open up new avenues for the analysis of the relationships between size, costs and outputs, and perhaps even facilitate some kind of consensus around the issues.

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Notes

1. In addition, the production of educational outcomes is cumulative. Student performance in year *t* is affected not only by the school and non-school inputs in this year, but in previous years. The difficulty of collecting historical data on school and non-school inputs leads to the use of outcomes for the previous year in "value-added" production models to capture these cumulative effects (Meyer, 1996). For simplicity in presentation, we are going to ignore the pretest in our implicit production function.

2. The difficulty of getting input quality is a problem for production functions in both the public and private sectors. Private sectors studies often attempt to get around the problem by using information on prices to proxy quality assuming that productivity differences are fully reflected in prices in competitive markets (Grabowski & Mehdian, 1990).

3. If enrollment size affects parent and student motivation, this implies that the impacts of student and parental characteristics on student outcomes are dependent on the size of the school or district. In other words, production and cost functions should include interactions between characteristics such as poverty, single-parent households, and parental education and enrollment size. As discussed in the literature review, Lee and Smith (1997) is one of the few studies to include this type of interaction.

4. See appendix Table A-1 for more detailed information on the variables and methodology used in these studies. This table is available on the website, http://cpr.maxwell.syr.edu/efap. We actually reviewed 15 cost function studies, but only included ten in the final analysis, because they either did not include student outcome data, or were estimated for other countries.

5. A number of states have specialized school districts that either serve elementary and middle school students or high school students. An interesting question is whether this form of specialization leads to higher student performance, and how the effects of these specialized districts interact with district size. We are not aware of any study that has examined economies of size in these types of districts.

6. Callan and Santerre (1990) handled environmental variables by creating quality adjusted enrollment measures. Student outcomes are regressed on student background variables, such as income and parent's education. The residual in index form is viewed as a measure of quality of school output, and is multiplied by the level of student enrollment.

7. One exception is Duncombe, Ruggiero, and Yinger (1996) who select outcomes based on their correlation with education demand variables. They find that measures of either the

lower end of the performance distribution (percent of students achieving basic competency), or upper end of the distribution (percent of students passing a more challenging set of high school exams) are more correlated with education demand than average test scores. Their result calls into question the use of average scores as the only measure of achievement.

8. Butler and Monk (1985) do employ an IV method, but most of their results appear to be based on OLS. Duncombe, Miner and Ruggiero (1995) do not treat outcomes as endogenous, but include a few demand related factors in the cost function.

9. The lack of factor price information in Ratcliffe, Riddle, and Yinger (1990) may not be a serious limitation in this study since it examines districts in Nebraska, and there is relatively little variation in teacher salary across districts.

10. Since teacher salaries are set by the school board, often through contract negotiations with teacher's unions, they are in fact determined simultaneously with budgets and outcomes. Only three studies (Downes & Pogue, 1994; Duncombe, Ruggiero, and Yinger, 1996; Reschovsky & Imazeki, 1997) have treated teacher salaries as endogenous.

11. Unfortunately, causation may run the other direction. Poor quality in public schools may lead to an increase in private school enrollment, implying that private school enrollment is in fact endogenous.

12. Callan and Santerre (1990) used a Box-Cox transformation of their variables, because some variables were measured as zero. It was not possible for this study to estimate scale elasticities with the reported statistics at other enrollment levels besides the mean. Gyimah-Brempong and Gyapong (1991) mean scaled their variables so that their log would equal zero at the mean. We used the coefficients on enrollment and enrollment squared to calculate the economies of size elasticities at other enrollment levels. We found that economies of size existed as long as enrollment was below 140,000 students.

13. None of the translog studies attempts to control for efficiency or the potential endogeneity of outcomes. In addition, Callan and Santerre (1990) used measures of scale that bundled together enrollment, student achievement, and student characteristics, so it is difficult to determine which dimension of economies of scale they were estimating.

14. While we have undoubtedly missed other studies, we have reviewed studies in the last 20 years that are frequently cited and/or those with strong methodology.

15. We did not include several other papers in the review because they did not include any teacher inputs in the production function. We did include the article by Lee and Smith (1997) even though it did not include school inputs in the production function, because the paper employs an interesting methodology that could be replicated with a more complete specification of the production function.

16. See appendix Table A-2 for more detailed information on the variables and methodology used in these studies. This table is available on the website,

http://cpr.maxwell.syr.edu/efap.

17. Eberts, Kehoe and Stone (1984) estimated a production function for small (1-200 students), medium (400-600 students) and large (over 800 students) elementary schools. They compare the coefficients between these three regression models to see if enrollment is associated with different production relationships. They found little difference in coefficients on student characteristics, or most school inputs across these different size classes. One exception was the teacher-student ratio which had a positive coefficient for small and large schools but a small negative coefficient for medium sized schools.

18. The quantitative case studies we have reviewed (Weast, 1997; Hall, 1993; Benton, 1992; Piercey, 1996) focus only on one school district, have no control group or do not use statistical controls, and have limited pre and post-consolidation data. Other case studies that do not make formal use of data can best be described as descriptive and speculative of the relationships we are interested in. The best of the case studies we have reviewed is by Streifel, Foldesy, and Holman (1991), who compare pre- and post-consolidation finance data in a national sample of 19 school districts. However, they don't include any controls for student achievement, teacher salaries, or changing student composition.

Table 1
Review of methodology in cost function studies of economies of size since 1980

Study	Outcome measures[a]	Factor prices	Teacher-quality adjustment	Socio-economic variables	Control for demand?	Control for efficiency?
Butler and Monk (1985)	P	1	No	2	No	Yes
Ratcliffe, Riddle, and Yinger (1990)	I	0	No	4	Indirect	No
Callan and Santerre (1990)	A, D	3	No	3	No	No
Gyimah-Brempong and Gyapong (1991)	A	3	Yes	3	No	No
Deller and Rudnicki (1992)	A	4	No	1	No	Yes
Downes and Pogue (1994)	A	2	Yes	5	Yes	Yes
Duncombe, Miner, Ruggiero (1995)	P, D	2	Yes	5	Yes	Yes
Duncombe, Ruggiero, and Yinger (1996)	P, D	1	Yes	5	Yes	Yes
Reschovsky and Imazeki (1997)	A	1	Yes	4	Yes	No
Reschovsky and Imazeki (1999)	A	1	Yes	5	Yes	No

[a] "A" denotes average test scores, "P" indicates percent passing, "D" denotes dropout rate or college going rate, "I" indicates use of a reduced form model where demand variables are substituted for outcomes.

Table 2
Review of economies of size results in cost function studies since 1980

Study	Sample	Enrollment measure	Economies of size results[a] (by type of spending)
Butler and Monk (1985)	Districts (New York)	Enrollment	Total- CR for large districts, ECS for small districts
Ratcliffe, Riddle, and Yinger (1990)	Districts (Nebraska)	Enrollment	Current-strong ECS
Callan and Santerre (1990)	Districts (Connecticut)	Quality-adjusted enrollment[b]	Variable-ECS
Gyimah-Brempong and Gyapong (1991)	Districts (Michigan)	Enrollment	Variable--ECS up to enrollment of 140,000[c]
Deller and Rudnicki (1992)	Schools (Maine)	Average daily attendance	Total-U (2000) with OLS, CR with frontier regression
Downes and Pogue (1994)	Districts (Arizona)	Enrollment	Operating--ECS
Duncombe, Miner, Ruggiero (1995)	Districts (New York)	Average daily membership	Total--U (6500) Instructional--U (1800) Transportation--U (1,200) Administration--ECS
Duncombe, Ruggiero, and Yinger (1996)	Districts (New York)	Average daily membership	Operating--U (3700)
Reschovsky and Imazeki (1997)	Districts (Wisconsin)	Enrollment	Total-U (5694)
Reschovsky and Imazeki (1999)	Districts (Texas)	Enrollment	Total minus transportation--U (6,700)

[a]Economies of size are denoted by ECS, diseconomies of size by DCS, and constant returns to size by CR. When there is a U-shaped function it is denoted by U, and the cost minimizing enrollment is indicated in parentheses.

[b]Calculated by taking the residual of a regression of average school test score on student characteristics, and multiplying it by primary or secondary enrollment. This measure folds enrollment, outcomes and student characteristics into one measure.

[c]Calculated by the authors using coefficients on enrollment and enrollment squared reported in this article.

Table 3
Review of methodology in production function studies of returns to size since 1980

Study	Outcome measures[a]	Teacher inputs	Other inputs	Socio-economic variables	Value added	Control for efficiency?
Summers and Wolfe (1977)	C	4	1	6	Yes	No
Kenny (1982)	A	4	2	11	No	No
Ebert, Kehoe and Stone (1984)	A	8	15	5	Yes	No
Felter (1989)	D	1	0	1	Yes	No
Fowler and Walberg (1991)	A, P	4	2	2	No	No
Deller and Rudnicki (1993)	A	1	3	3	No	Yes
Lee and Smith (1997)	C	0	0	3	Yes	Yes
Sebold and Dato (1981)	A	1	3	3	Yes	No
Baum (1986)	A	1	0	3	No	No
Walberg and Fowler (1987)	A	1	0	1	No	No
Ferguson (1991)	A	3	0	5	Yes	No
Ferguson and Ladd (1996)	A	4	0	8	Yes	Yes

[a]"A" denotes average test scores, "P" indicates percent passing, "D" denotes dropout rate or college going rate, "C" indicates use of a change in test scores across two different years.

Table 4
Review of returns to size results in production function studies since 1980

Study	Sample	Enrollment measure	Returns to size results[a]
Summers and Wolfe (1977)	Elementary schools (Philadelphia)	School enrollment	CR (white) DRS (black)
Kenny (1982)	High schools (national sample)	School enrollment	IRS
Ebert, Kehoe and Stone (1984)	Elementary schools (national sample)	School average daily attendance	DRS (medium to large) CR (small to medium)
Felter (1989)	High schools (California)	School enrollment	DRS
Fowler and Walberg (1991)	Secondary schools (New Jersey)	School enrollment	CR or DRS
Deller and Rudnicki (1993)	Elementary schools (Maine)	School enrollment	DRS
Lee and Smith (1997)	High schools (national sample)	School enrollment	600-900 is optimal size for low and high SES schools. Low SES students especially hurt in large (1000+) schools
Sebold and Dato (1981)	Large districts (California)	District average daily attendance	CR (elementary tests) IRS (high school tests)
Baum (1986)	Districts (LA county)	District average daily attendance	CR
Walberg and Fowler (1987)	Districts (New Jersey)	District average daily attendance	DRS (all tests)
Ferguson (1991)	Districts (Texas)	District/school enrollment	DRS (district) DRS or CRS (school)
Ferguson and Ladd (1996)	Elementary schools (Alabama)	District enrollment	IRS

[a]Increasing returns to size are denoted by IRS, decreasing returns to size by DRS, and constant returns to size by CR.