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Consolidating Rural School Districts: Potential Savings and Effects on Student Achievement

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ABSTRACT

One frequently proposed policy is to consolidate rural school districts in order to save money by obtaining economies of size. The effects of school district size on both expenditures and standardized test scores are estimated for Oklahoma. Results indicate that economies of scale with respect to expenditures per student exist up to an average daily membership (ADM) of 965 students, but that as school districts become larger, tests scores decline. Even if savings in school district administration from consolidation are spent on instruction, state average test scores would decrease slightly. Thus, school district consolidation can reduce costs, but it will also reduce student learning.

Key Words: *economies of size, education, plateau function, school district consolidation.*

The efficient use of educational funds has been a topic of research since the late 1950s. Various studies have shown that economies of scale exist in public schools, and that by consolidating small school districts a more efficient use of school resources can be achieved. Most of these studies focus on economies of scale in the average cost function of school districts, but ignore the effect of school district consolidation on school quality.

Researchers such as Riew (1966, 1986), Cohn, White and Tweeten, and Lewis and Chakraborty have found that economies of scale exist in public schools with respect to average cost per student. Their research was done on school districts in Wisconsin, Iowa, Oklahoma, and Utah, respectively. Riew (1986) and Cohn found that economies of scale exist up to between 1,500 and 1,700 average daily attendance (ADA), while White and Tweeten found economies of scale up to 800 ADA. Increasing returns to scale are also known to exist in other areas of rural public finance such as rural transportation costs (Deller and Nelson). Most of these studies find that administrative or management cost is the main cause of decreasing per-unit cost.

In spite of these apparent economies, consolidation usually faces strong opposition in the districts being consolidated. One reason that those in small school districts resist consolidation is that they perceive receiving fewer educational and non-educational benefits if they are forced to attend a large school. Fowler and Walberg, Eberts, Kenhoe and Stone, and Wendling and Cohen found school size to be negatively related to student performance, even after controlling for demographics. But-

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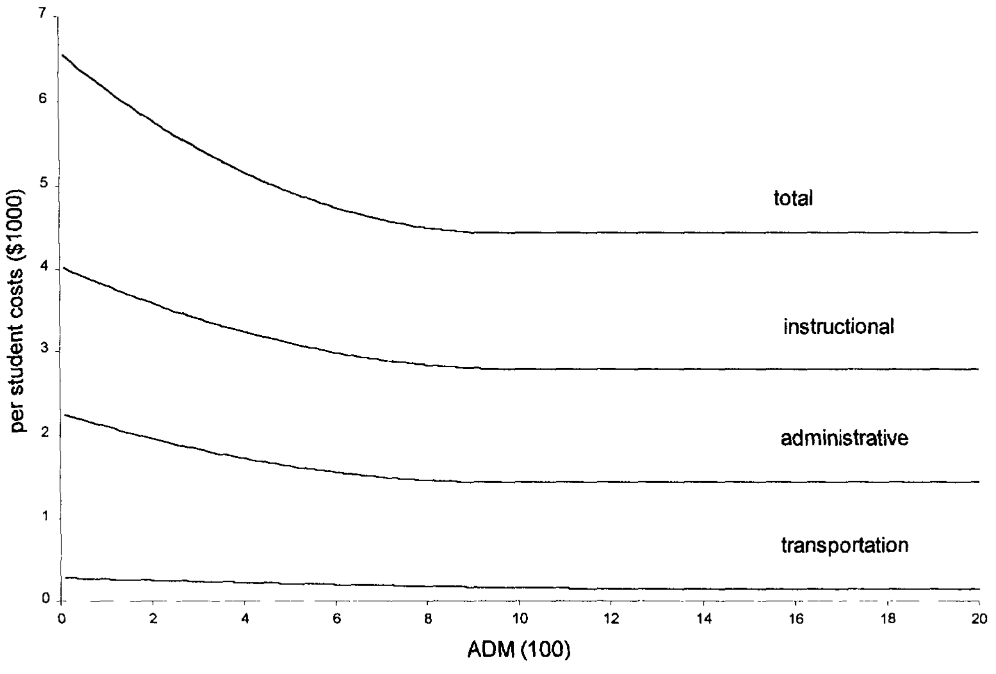

Figure 1. Estimated average variable cost functions for Oklahoma school districts

ler and Monk argue that smaller rural schools are more efficient than larger suburban and urban schools. They give three reasons for the efficiency of rural schools: a) rural districts are usually more homogeneous than urban communities, making teaching more productive and requiring fewer administrative personnel, b) rural communities may be more stable than urban communities, and c) there are usually fewer outside activities that compete with schooling in rural communities.

The objective of this research is to determine the economies of scale with respect to average cost per student for Oklahoma public school districts. An additional objective is to determine whether increasing school district size affects the quality of education as measured by achievement test scores. This research differs from previous studies on school district economies of scale in both methods and type of data used. A plateau function is used to estimate economies of scale in the average variable cost function. This functional form indicates that above a certain school district size constant economies of scale exist with respect to costs. This approach to the cost function is similar to the von Liebig approach to production used by Paris and Frank, Beattie, and Embelton. Also, a production function is estimated with school district test scores as the output (a measure of school quality) and various student, parental, and school variables as inputs (Hanushek, 1986, 1996, 1997). Hierarchical modeling is used. A correction is made for heteroscedasticity to improve the precision of the tests in both the cost and school-quality functions. Previous research has either concentrated on cost savings from school district consolidation without regard to school quality or used variables such as graduation rate as a quality variable when conducting the analysis jointly. This research goes beyond past studies in that we use achievement test scores by school district as a proxy for educational quality. This paper is also the first to look at whether test scores could be increased in a consolidation by reallocating the administrative cost savings to instruction.

Data

Data for this research were obtained from the Oklahoma Department of Education (1996) for the 1994–1995 school year. There were

557 school districts in Oklahoma in 1994–1995. Because of confidentiality, only 547 are used in this analysis (scores for school districts with fewer than six students taking a test were not reported).

Test scores by subject and grade were available for each school district for the school year 1994–1995. Subjects covered by the tests were reading, science, and math. Achievement test results were from a Criterion Referenced Test (CRT), which is unique to Oklahoma, and the Iowa Test of Basic Skills (ITBS). The ITBS is a norm-referenced test. Our approach does not consider whether the tests are norm referenced or criterion referenced since we use raw scores. The CRTs are much easier tests and so scores on it are higher. The CRT is given to grades 5, 8, and 11. The ITBS is given to grades 3 and 7. All types of tests were equally weighted.

Problems arise when test scores are used as a measure of school performance. These problems are a) tests scores are a one-shot measure of learning, imperfect measures of knowledge, and fail to measure all areas of knowledge; b) schools and teachers may adapt their procedures to "teach to the test"; and c) test scores are due in part to schools, but also include student aptitude, social class, and other causes (Chubb and Moe, p. 198; Deaton and McNamara). In addition to all this, using average test scores loses information about the variance within a school and, thus, a school's ability to produce equitable outcomes cannot be measured. Schools also teach social skills and a variety of other skills such as music and athletics which are not reflected in achievement test scores. Since special education students usually do not take the tests, test scores do not measure how well schools are teaching these students. Also, CRTs do a poor job of measuring how well schools are teaching their most gifted students. It is important to recognize the limitations of using test scores as a proxy for school performance, such as their inability to measure student aptitude (Borland and Howsen). In spite of their limitations, test scores are an accurate measure of student knowledge and imparting knowledge is certainly the primary goal of schools.

Cultural and socioeconomic background determine the ability of pupils to use educational inputs (Deaton and McNamara). Student data included were the number of students for each gender and each race by grade for each school district. Race data include Black, Hispanic, Native American, and White. Parental data were derived from the 1990 census (United States Department of Education) and refer to parents with school-age children. The parental data include proportion with at least a bachelor's degree, proportion with some college, proportion with a high-school education, and proportion without a high school education. Other demographic data by school district were proportion of students obtaining a free or reduced-price lunch. The free lunch variable is important because it reflects both family income and family size.

Proportion of special education students by school district was used because special education students are expected to require more individual attention and thus be more costly to teach. Some schools are more restrictive than others about whom they allow to take the tests. Schools can increase average tests scores by not letting their weaker students take the tests. We use the percentage of students enrolled in each grade who actually took the test to correct for differences due to this practice.

ADM indicates school districts' average daily enrollment. ADM for the Oklahoma school districts used in this research ranged from 20 students to 40,160 students. ADM was used to calculate per-student expenditures. Expenditures per student were divided into three categories: instructional, administrative, and transportation. Fixed costs, such as sinking fund and bond payments, were not included.

School District Average Variable Cost

Plots of the residuals from the regression of expenditures against ADM and proportion of special education indicated that a plateau function would be appropriate. The following average cost equation was estimated using nonlinear optimization in SAS:

(1) $C = \alpha S + \lambda HI_{(ADM<M)} + BI_{(ADM\geq M)} + \delta D + \epsilon.$

C is a 547 × 1 vector of the average variable cost per student, S is a 547 × 1 vector of proportion of special education students, and H is a 547 × 2 matrix with average daily membership (ADM) in the first column and ADM squared in the second one. D is a 547 × 1 vector of population density for the 1995–1996 school year since data from the previous year were not available. $I_{(x)}$ is an indicator function and M is a constant denoting the level of ADM corresponding to the corner of the spline function. If ADM is greater than or equal to M, then C is equal to $\alpha S + B + \delta D$, but if ADM is less than M, C equals $\alpha S + \lambda H + \delta D$. Continuity at the point ADM = M was imposed, and ϵ is a heteroskedastic error term.[1] Multiplicative heteroscedasticity is assumed, so variance is modeled as:

(2) $\sigma_i^2 = \exp(\gamma' z_i)$

where $z_i = [1 ADM_i ADM_i^2]$ and $\gamma = [\ln \sigma^2 \alpha_1 \alpha_2]$ are the parameters to estimate. The index i designates school district. Correction for multiplicative heteroscedasticity was performed using-maximum likelihood as described in Greene (p. 567). This correction provided asymptotically efficient parameter estimates. Estimation of (1) was performed using separate equations with a) average variable costs (administrative plus instructional plus transportation expenditures), b) average administrative costs, c) average instructional costs, and d) average transportation costs as the dependent variable. All costs were calculated on a per-student basis. The proportion of special education students was not significant in the administrative costs equation as expected, and was therefore removed from it. Also, density was eliminated from the administrative and instructional cost equations, once the non-significance of its parameter estimate supported the lack of theoretical reasons for density to serve as an explanatory variable.

School Quality

The regression for school quality has school district average achievement scores on standardized tests as the dependent variable and inverted average daily membership by school district as an independent variable. Various socio-economic and school factors are also included to correct for other factors that influence test scores. The data can be viewed as a panel with cross-sections of school districts observed fifteen times each, at most.[2] A hierarchical linear model, which is a random effects model with adapted degrees of freedom, is used (Arminger *et al.*, 531). This model allows introducing a common correlation among observations from a single school district and is estimated using PROC MIXED in SAS. Because school district averages are from differing number of students, heteroscedasticity is expected. The model used for variance is the one presented in equation (2) where z is now a vector whose first element is one and the others are values for all the explanatory variables used in the quality function and the number of students taking the test. The index I now represents each particular kind of test/grade/school district combination. Maximum likelihood estimation (MLE) is used to gain asymptotically efficient parameter estimates and valid hypothesis tests (Greene, 567). The MLE is performed by iterating around the hierarchical linear model.

The following equation was estimated using maximum likelihood estimation:

(3) $Y = \rho G + \beta S + \Phi X + \eta A + \epsilon$

[1] Butler and Monk (1985) suggest including a measure of quality in the cost function. Following Butler and Monk's ideas, the cost function was reestimated by two-stage least squares with quality included as an explanatory variable. The reduced form was obtained for quality. Then an instrumental variable estimate for school quality was obtained by averaging the estimates over grades and kinds of tests. This estimate was introduced in the instructional and total cost functions but was not significant in either case. Thus the recursive system used for the cost and quality equations could not be rejected.

[2] Recall that five grades have been used for the analysis and within each grade three kinds of tests may be taken by the students. This gives 15 observations at most for each school district.

Table 1. Number of Oklahoma School Districts by Size, Percent of Total State Average Daily Membership, Percent of Special Education Students Enrolled and Expenditures per Student

				Expenditures per Student ($)[a]		
ADM	N	Percent of total ADM	Percent of Spec. Ed.	Adminis-tration and Transp.	Instruction	Total
Fewer than 100	35	0.4	13.0	2,827	4,145	6,973
100–200	89	2.3	14.3	2,271	3,777	6,048
200–300	79	3.3	12.6	2,101	3,457	5,559
300–400	65	3.7	13.1	2,027	3,288	5,315
400–500	65	4.9	12.3	1,901	3,205	5,106
500–1,000	91	11.1	12.0	1,679	2,905	4,584
Greater than 1,000	123	74.4	10.9	1,583	2,780	4,363

[a] Expenditures do not include long-term costs such as bond payments and sinking fund.
Note: The means are unweighted averages of each district's proportion and therefore they will not match state averages.

where Y is a vector of test scores for school districts, G is a matrix of dummy variables that includes the type of test (ITBS or CRT), the kind of test (math, reading, or science), and grade level of the test (third and seventh for the ITBS, and fifth, eighth, and eleventh for the CRT). The variable for CRT, grade 11, math test was included as part of the intercept.

The matrix S contains student effects which vary by school district and grade. Student effects are proportions for each grade by race and gender, and the percent of students taking the tests. Since the proportions by race and gender sum to 1, this procedure required leaving one variable in the intercept, which was white males.

The socioeconomic effects matrix X varies only by school district. It includes the percent of students in special education, the percent of students receiving free or reduced-price lunches, two expenditure-per-student variables (instructional and administrative), and four levels of educational attainment of the parents. The proportion of parents without a high school education was left in the intercept, since the total summed to 1. A is a vector of inverted average daily membership values and ϵ is a heteroscedastic error term.[3]

Results

The number of school districts by ADM and total average variable costs are shown in Table 1. There are 123 of the 547 school districts with greater than 1000 ADM. School districts with greater than 1000 ADM accounted for 74.3 percent of the state's total public school enrollment in 1995. Those with over 500 ADM had more than 85 percent of the state's total enrollment. As ADM increases, the average cost-per-student decreases. However the decline in average cost is small, above 500 ADM. The percentage of special education students drops as district size increases. Table 2 shows descriptive statistics of the variables used in the estimation procedures.

Results show that economies of scale exist in Oklahoma public school districts. As Table 3 shows, the estimated spline function indicates that for school districts larger than 965 average daily membership no significant economies of scale exist. The plateau for average variable costs is $4430 per student. An increase in special education students increases instructional and transportation costs and therefore proves to be an important variable in the average total cost function.

The transportation cost function is almost

[3] At a reviewer's request, two other variables were tested for inclusion in the model: density and an interaction term for instructional and administrative average costs. These variables were added independently and their p-values were calculated at 0.1442 and 0.1055 respectively. Therefore, they were not included in the final model.

Table 2. Descriptive Statistics for Oklahoma School Districts

Variable	Mean	Std. Deviation
Average test score[a]	49.59	26.48
Parents wo/high school education	0.20	0.09
Parents w/high school education	0.39	0.10
Parents with some college	0.28	0.09
Parents with Bachelor's degree	0.13	0.08
Parent's median income ($)	26,438.00	7,015.00
Proportion Black males	0.02	0.06
Proportion Black females	0.02	0.06
Proportion Indian males	0.11	0.12
Proportion Indian females	0.11	0.11
Proportion Spanish males	0.01	0.03
Proportion Spanish females	0.01	0.03
Proportion White males	0.38	0.14
Proportion White females	0.34	0.13
Proportion free or reduced lunch	0.54	0.18
Proportion special education	0.12	0.04
Proportion taking tests	0.89	0.10
Average daily membership[b]	1,163.00	3,190.00
Total Expenditures per student[c]	5,121.00	1,127.00

Note: The means are unweighted averages of each district's proportion and therefore they will not match state averages.
[a] These are average per-student test scores, across all achievement tests.
[b] Average daily school district student membership.
[c] Total expenditures per district divided by average daily membership.

linear and economies of scale barely exist for small and medium-sized school districts. A school district with 150 ADM will spend approximately $255 per student for transportation whereas another with 1500 or higher ADM spends $119 per student. Density is a highly significant explanatory variable. Transportation costs in Oklahoma are less than 5 percent of average total variable cost, so an increase in transportation costs due to consolidation would have only a small effect on total costs. A few districts in Western Oklahoma are so large that transportation costs could become an important factor. However, Oklahoma law has a provision allowing school districts covering a large area to continue to receive state support even if they do not meet minimum ADM requirements.

The minimum average cost for total, administrative, and instructional expenditures was reached (the corner of the plateau) at 965 ADM, 998 ADM, and 985 respectively. This indicates that school districts' economies of scale are about the same whether average administrative costs, average instructional costs, or average total variable costs are used. The slope of the average cost function for administration is less steep than that for instruction, indicating that the effects of economies of scale are greater for instruction expenditures (Figure 1).

Table 4 includes the parameters describing school quality. As expected, an increase in the proportion of parents with either some college or at least a bachelor's degree results in an increase in achievement test scores. Results showed that school districts with more minority students have lower achievement test scores, similar to Hanushek's (1986) and Sander's findings. The parameter describing students receiving subsidized lunches is negative and significant, indicating that as the percentage of a school's students receiving subsidized lunches increases, achievement test scores decrease. The subsidized lunch variable is also an indication of a district's median income of parents. As the percentage allowed to take tests increases, the average test scores decrease. Instructional expenditures are positive and statistically significant. Expenditures for

Table 3. Parameter Estimates for Oklahoma School District Average Cost Function

Variable	Parameter Estimate	Asymptotic Std. Error
Average Total Variable Costs		
Constant ($1000)	6.23	0.026
Proportion Special Education	2.94	1.022
Density (ADM/area)	−0.10	0.039
ADM/100	−0.45	0.072
(ADM/100)Squared	0.02	0.005
Corner of Plateau—Costs ($1000)	4.43	
Corner of Plateau—ADM (100)	9.65	
Average Instructional Variable Costs		
Constant ($1000)	3.85	0.131
Proportion Special Education	1.49	0.626
ADM/100	−0.25	0.040
(ADM/100)Squared	0.01	0.003
Corner of Plateau—Costs ($1000)	2.78	
Corner of Plateau—ADM (100)	9.98	
Average Administration Variable Costs		
Constant ($1000)	2.27	0.074
ADM/100	−0.17	0.030
(ADM/100)Squared	0.01	0.002
Corner of Plateau—Costs ($1000)	1.43	
Corner of Plateau—ADM (100)	9.85	
Average Transportation Variable Costs		
Constant ($1000)	0.26	0.020
Proportion Special Education	0.21	0.105
Density (ADM/area)	−0.01	0.003
ADM/100	−0.02	0.004
(ADM/100)Squared	0.0006	0.0002
Corner of Plateau—Costs ($1000)	0.15	
Corner of Plateau—ADM (100)	14.93	

Note: The estimation method used was iterated generalized least squares. Multiplicative heteroscedasticity was assumed and the above variables were used in the variance equation.

administration are negative and statistically significant at the 10-percent level. This indicates that school districts which spend more on instruction and less on administration have students that perform better on achievement tests. Brewer argued that money spent on administration could reduce quality of education because administrators may use up students' or teachers' time. Ferguson and Ladd found that increased spending on classroom instruction has a positive effect on test scores, although Hanushek (1986, 1996, 1997) has long argued that spending has little effect. Our research confirms the arguments of Brewer and Ferguson and Ladd and only mildly disagrees with Hanushek as the effect of increased spending is small.

Our parameter of interest is the inverse of ADM/100, which indicates whether diseconomies of scale exist for schools' quality of education.[4] When ADM equals 100, the param-

[4] Equations with linear a function of ADM and the square root function of ADM were estimated as alternative functional forms. The results from these functional forms were similar to that of the inverse ADM function. They all indicate diseconomies of scale in test scores. The ADM coefficient of the linear function did not have the statistical significance of the inverse of ADM parameter, and was deemed inappropriate because it indicates that increasing school district size by

Table 4. Parameter Estimates for Quality of Schooling Using Average Achievement Test Scores as the Dependent Variable

Variable	Parameter Estimate	Pr > |t|
Intercept	77.82	0.0001
Grade 3 math	−50.03	0.0001
Grade 3 reading	−58.05	0.0001
Grade 3 science	−57.44	0.0001
Grade 5 math	−2.86	0.0001
Grade 5 reading	5.73	0.0001
Grade 7 math	−50.25	0.0001
Grade 7 reading	−53.05	0.0001
Grade 7 science	−50.16	0.0001
Grade 8 math	−0.98	0.0002
Grade 8 reading	0.83	0.0004
Grade 8 science	−2.33	0.0001
Grade 11 reading	−7.65	0.0001
Parents/Bachelor's degree	3.09	0.0001
Parents w/some college	1.43	0.0530
Parents w/high school education	0.37	0.6260
Proportion White female	−0.14	0.7291
Proportion Black female	−2.75	0.0666
Proportion Indian female	−0.65	0.1955
Proportion Spanish female	−0.22	0.8445
Proportion Black male	−2.66	0.0503
Proportion Indian male	−0.53	0.2717
Proportion Spanish male	−2.51	0.0308
Percent subsidized lunch	−1.01	0.0085
Percent special education	−1.48	0.2900
Percent taking test	−3.25	0.0001
Administrative Expenditures ($1000)	−0.29	0.0896
Instruction Expenditures ($1000)	0.37	0.0041
Inverse of Average Daily Membership (100)	0.64	0.0062

Note: The grade/test variables are intercept-shifting dummy variables. The estimation method used was iterated generalized least squares. Multiplicative heteroscedasticity was assumed and number tested was used in the variance equation along with the above variables.

eter adds 0.64 to achievement test scores. For ADM equal to 1,000, the parameter adds 0.064 to achievement test scores. As ADM becomes bigger the effect decreases even more. This indicates the effect of increasing school district size results in lower achievement test scores.[5]

Ostrom (1998) argues that small public agencies often operate more effectively than large ones. Some of the reasons she gives for inefficiency in police departments in metro-

one student decreases test scores by the same magnitude whether the school district size is 20 or 40,000. The square root function had statistically significant parameter estimates when linear and square root parameters were tested jointly (0.02 significance). The minimum test scores were at 8,100 ADM. This functional form was considered inappropriate because few school districts are near 8,100 ADM, and there is no evidence to conclude test scores should increase above 8,100 ADM. Also we were interested in rural school districts, typically with less than 1,000 ADM, and the square root function did not fit the data well in that range.

[5] Plots of the residuals without ADM included showed that a few of the smallest school districts (most with ADM less than 50) did very poorly on the achievement tests. Test scores may have been hurt from having one teacher teach multiple grades. Thus students in schools that cannot afford one teacher per grade may benefit from consolidation.

politan areas may well apply to rural school districts. Education requires the active involvement of citizen consumers (students and parents) for input resources to have a beneficial effect. Parents are likely to participate more in small schools. The head of the public agency (superintendent) can monitor internal performance based on more detailed and accurate information in a small unit rather than a large one.

Discussion

The first objective of this research was to determine the economies of scale with respect to average cost per student for Oklahoma school districts. As Figure 1 shows, economies of scale for school expenditures in Oklahoma exist up to an average daily membership of 965. From ADM of 100 to 1000, total variable costs decline by $1738 (28 percent) per student, instructional costs decline by $1007 (26.6 percent) per student, administrative costs decline by $679 (32.2 percent) per student, and transportation costs by $119 (44.8 percent) per student. At first glance it appears that savings from school district consolidation could provide more funds for increasing the number of teachers or purchase of teaching tools such as computers. This makes economic sense if the consolidation does not require additional capital expenditures, such as buildings.

An additional objective was to determine whether increasing average school district size affects the quality of education as measured by achievement test scores. Achievement test scores were inversely related to ADM, and the effects were stronger as school districts became smaller. Most of the effects of diseconomies of scale are for school districts less than 1000 ADM.

Parameter estimates from Table 4 indicate that consolidating small school districts into larger ones would lower achievement test scores (The ADM inverse parameter). This decrease in quality occurs even when controlling for socio demographics and school expenditures. The net effect of consolidation on school quality depends upon how losses from the students in the small school district compare to the gains by the students in the large. Students from the large school district would have increased test scores if all money saved were spent on instruction exclusively. If a school district with 100 ADM was merged with one having 1000 ADM, an extra $158 per student could be assigned for instruction. But the gains in achievement test scores for the students of the large school would be very small, only about 0.05 points. In the calculation it has also been considered that students would experience a small loss in achievement test scores because of the increased school size.

For students from small schools, consolidation not only decreases expenditures per student on administration, but also on instruction (see Figure 1). Goetz and Debertin's results suggest that most of the differences in instructional expenditures are due to differences in pupil-teacher ratio. For instance, a reduction of $1007 on instruction expenditures per student would result if a school of 100 ADM were merged with one of 1000 ADM (Figure 1). Our estimates indicate that under this scenario a student from the small school would lose 0.7 points on achievement test scores. As a result of the consolidation the students from small schools are big losers. From the macro level the state's average achievement test scores drop slightly due to consolidation even if the money saved is reallocated to instruction. Other costs of consolidating school districts can only be measured outside the marketplace (Tholkes). In some rural communities the school is an important place for social interaction. Loss of the local school may cause the community to lose an important part of its identity and could disintegrate social ties within the community. Politically, because the students from the small school district are big losers from the merger, the parents of the students from the small school would likely fight the consolidation.[6]

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[6] Here the example from the Discussion section is presented in more detail. Calculations were performed before rounding. Assume an average school district (called School District A) with 100 ADM was merged

Conclusion

If the objective of school district consolidation is simply to save money by establishing school districts that operate on the minimum cost curve, the answer is to consolidate small school districts, if we assume that excess capacity exists (no additional building and equipment costs). However, if school quality is considered, school district consolidation may result in decreasing the state's average achievement test scores.

Finally, not all small school districts exhibit higher achievement test scores than larger districts. In addition to this, some small school districts do not spend as much per student as larger districts. If a policy of consolidation is implemented it should be on a case-by-case basis, with evaluation of the cost per student and achievement test scores of the school districts in question. Oklahoma's current policy that provides financial incentives to merge and only imposes merging on very small districts seems like a reasonable policy.

References

Arminger, G., C. C. Clogg, and M. E. Sobel. *Handbook of Statistical Modeling for the Social and Behavioral Sciences,* Chapter 10, Random Coefficient Models. New York, NY: Plenum Press, 1995.

Blackburn, M. L., and D. Newmark. "Are OLS Estimates of the Return to Schooling Biased Downward? Another Look." *Review of Economics and Statistics* 77(May 1995):217–230.

Borland, M. V., and R. M. Howsen. "Competition, Expenditures and Student Performance in Mathematics: A Comment on Couch et al." *Public Choice* 87(1996):395–400.

Brewer, Dominic J. "Does More School District Administration Lower Educational Productivity? Some Evidence on the 'Administrative Blob' in New York Public Schools." *Economics of Education Review* 15(2)(1996):111–124.

Butler, R. J., and D. H. Monk. "The Cost of Public Schooling in New York State: The Role of Scale and Efficiency." *The Journal of Human Resources* 20(Summer 1985):361–381.

Chubb, John E., and Terry M. Moe. *Politics, Markets, and America's Schools.* Washington, DC: The Brookings Institution, 1990.

Cohn, E. "Economies of Scale in Iowa High School Operations." *Journal of Human Resources* 3(Fall 1968):422–434.

Deaton, Brady J., and Kevin T. McNamara. "Education in a Changing Environment: Impact of Population and Economic Change on the Demand and Cost of Public Education in Rural America." SRDC Synthesis-Bibliography Series No. 18. Mississippi State, MS: Southern Rural Development Center, 1984.

Deller, Steve C., and Carl H. Nelson. "Measuring the Economic Efficiency of Producing Rural Road Services." *American Journal of Agricultural Economics* 73(1)(February 1991):194–201.

Eberts, R. W., E. Kehoe, and J. A. Stone. "The Effect of School Size on Student Outcomes." Eugene, OR: Oregon University (ERIC Document Reproduction Service No. ED 245 382), 1984.

Frank, Michael D., Bruce R. Beattie, and Mary E. Embelton. "A Comparison of Alternative Crop Response Models." *American Journal of Agricultural Economics* 72(3)(August 1990):597–603.

Ferguson, Ronald F., and Helen F. Ladd. "How and Why Money Matters: An Analysis of Alabama Schools." *Holding Schools Accountable.* Washington, DC: The Brookings Institution, 1996.

Fowler, William J., and Herbert J. Walberg. "School Size, Characteristics, and Outcomes."

with another average school district (School District B) with 1,000 ADM to create School District A–B. Since A–B's average variable cost is only $4,422 per student, district B would gain $1,738 per student from A (a total of $173,800 or $173,800/1,100 = $158.02 per student). If A–B decides to spend all the extra money on instruction, the gain in test scores for a student originally from B would be $0.158 thousand times the parameter for instruction (0.37) or 0.06 points. However, students coming from A face another scenario. The reduction in instructional expenditures for the students from District A is $849.6 per student. (The instructional expenditure difference from a 100 ADM school district and a 1000 ADM school district is $1007. This is subtracted from $158.02 to obtain the $849.6 reduction.) Because of this, students lose 0.31 points each. But there is also a loss due to increased ADM of 0.58 points (the inverse ADM parameter multiplied by (1/11) − 1), and a gain of 0.19 points per student due to reduced administrative costs. All these effects add to a net reduction of 0.7 points for each student originally from A. This does not include the non-market costs of consolidation to the students in small schools, such as costs of adjusting to a new environment.

Educational Evaluation and Policy Analysis 13(2)(Summer 1991):189–202.

Goetz, Stephan J., and David L. Debertin. "Rural Education and the 1990 Kentucky Educational Reform Act: Funding, Implementation, and Research Issues." Agricultural Economics Research Report 54, Lexington, KY, August 1991.

Greene, William H. *Econometric Analysis* Third Edition, Chapter 12, Heteroscedasticity. Upper Saddle River, NJ: Prentice-Hall, 1993.

Hanushek, Eric A. "Assessing the Effects of School Resources on Student Performance: An Update." *Educational Evaluation and Policy Analysis* 19(2)(Summer 1997):141–164.

Hanushek, Eric A. "School Resources and Student Performance." *Does Money Matter?* (edited by Burtless, Gary) Washington, DC: The Brookings Institution, 1996.

Hanushek, Eric A. "The Economics of Schooling: Production and Efficiency in Public Schools." *Journal of Economic Literature* 24(September 1986):1141–1177.

Lewis, W. C., and K. Chakraborty. "Scale Economies in Public Education." *Journal of Regional Analysis and Policy* 26(1)(1996):23–35.

Oklahoma Department of Education. Unpub. electronic data. Oklahoma Department of Education, Oklahoma City, OK., 1996.

Ostrom, E. "The Comparative Study of Public Economies." The American Economist 42(1) (1998):3–17.

Paris, Quirino. "The von Liebig Hypothesis." *American Journal of Agricultural Economics* 74(4)(November 1992):1019–1028.

Riew, J. "Economies of Scale in High School Operations." *Review of Economics and Statistics* 8(August 1966):280–287.

Riew, J. "Scale Economies, Capacity Utilization, and School Costs: A Comparative Analysis of Secondary and Elementary Schools." *Journal of Education Finance* 11(Spring 1986):433–466.

Sander, William. "Catholic High Schools and Rural Academic Achievement." *American Journal of Agricultural Economics* 79(1)(February 1997): 1–12.

Tholkes, R. J. "Economies of Scale in Rural School District Reorganization." *Journal of Education Finance* 16(Spring 1991):497–514.

United States Department of Education. "1990 Census Data by School District." Washington DC. National Center for Education Statistics, United States Department of Education (CD Rom), 1995.

Wendling, W. W., and J. Cohen. "Education Resources and Student Achievement: Good News for Schools." *Journal of Education Finance* 7(1981):44–63.

White, Fred, and Luther Tweeten. "Planning Educational Services." *Southern Journal of Agricultural Economics* 4(1)(July, 1972):23–28.