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A Case for Consolidation

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INEFFICIENT EDUCATION SPENDING IN PUBLIC SCHOOL DISTRICTS:
A CASE FOR CONSOLIDATION?

MARVIN E. DODSON III and THOMAS A. GARRETT*

ABSTRACT

This paper estimates scale economies for Arkansas school districts. Large economies of scale exist in teacher salary and supply costs, as well as total costs. Our results suggest that districts, especially rural districts, would experience measurable cost-savings from consolidation. We simulate a hypothetical rural school district consolidation to obtain cost-saving estimates from consolidation. Simulations indicate that districts could save an average of 34 percent in average variable costs. At the state level, consolidation of rural districts in Arkansas could annually save \$40 million. However, consolidation of school districts may increase various implicit costs to students and local communities. (JEL I22, I28)

I. INTRODUCTION

The passage of the No Child Left Behind Act of 2001 (Public Law 107-110) highlights the continuing problems associated with funding quality primary and secondary public education in the United States. In large part, this new legislation places greater responsibilities on state and local governments in terms of funding and standards. The variation in state-level education funding, fiscal capacity, and educational outcomes are all of interest in this legislation. While debate will continue as to the effectiveness of the new legislation, one fact is clear; state and local governments must fund these new responsibilities while balancing tight budgets and facing greater demand for education services.¹

The current state budget crises are creating a further obstacle to improving and funding public education. State budget deficits for FY 2002 totaled \$37 billion, and estimates for FY 2003 forecast a collective budget deficit of nearly \$50 billion.² These fiscal pressures at the state level are equaled by financial pressures at the local level, forcing local officials across the country to make drastic cuts in school district expenditures. As an example, several school districts in California will experience cuts ranging from \$23 million to \$52 million over the next year; and many Minnesota school districts are facing cuts in the \$10 million to \$20 million range.³

Financing education is as an important responsibility for state and local governments. In fiscal year 1999, state governments spent \$126 billion on higher education and local governments spent over \$350 billion on primary and secondary education. These totals represent 13 percent and 38 percent of total expenditures, respectively. Of particular interest here are per pupil expenditures at the primary and secondary levels.⁴ The national average per pupil expenditure in

1999 was \$6,638. Alaska ranks number one with per pupil expenditures of \$10,600, and Mississippi ranks fiftieth with an expenditure of \$4,658 per student. Regarding the state studied here, Arkansas invested \$5,545 of state funds per enrolled student (rank of 42) during the 1999 academic year. This figure includes expenditures on capital outlays, interest on debt, and programs that support adult education. Excluding these categories produces current expenditures that are more representative of spending on instruction and student support activities at the primary and secondary levels. On this basis, Arkansas per student funding was \$4,752.⁵

In order to meet legislated responsibilities and ease increasing budget pressures, we argue that state and local governments can attend to the inefficiencies that plague their K-12 education production process. The inefficiency is the distribution of education funding across far too many, and far too costly, administrative units. A consolidated school district can produce an equivalent level of output at a lower cost per student by avoiding redundant expenditures. For example, a consolidated district would require fewer administrators or specialized instructors than is required when the same enrollment level is disjoint across separate districts. We show that exploiting the economies of scale in the education production functions of Arkansas school districts can provide measurable cost-savings. These savings could be used in whatever manner deemed appropriate, including measures intended to increase the quality of education.⁶ While these costs are easily quantified, there are also several implicit costs from consolidating that may prevent the full dollar savings from being realized.

Previous research on education scale economies is extensive (see Fox, 1981; Callan and Santerre, 1990; Duncombe, Miner and Ruggiero, 1995; Duncombe, Ruggiero, and Yinger, 1996; and Andrews, Duncombe, and Yinger, 2002 for a sample of the work done in this area). This

paper contributes to the literature in several ways. First, we estimate scale economies for school districts in Arkansas, a state that has not received attention in the literature. While most studies have found significant economies of scale in the production of education, there is significant variation in the magnitude of this scale.⁷ Thus, there is no reason to assume that the findings in a particular state can be generalized to all states. We compute cost elasticities for total variable costs as well as for transportation, teacher salary, and supply costs. Our estimates are somewhat different than those obtained by Duncombe, Miner and Ruggiero (1995) who performed a similar analysis for New York school districts. This paper also accounts for the endogeneity of several student outcome measures and input prices, while at the same time providing more direct measures of inefficiency through the use of Stochastic Frontier Analysis (SFA).

Many studies on scale economies in public education implicitly suggest that cost-savings could be had from consolidation. Here we attempt to quantify the cost-savings of consolidating school districts by simulating a consolidation scenario where several neighboring rural, low-enrollment school districts are consolidated into a single district. In addition, while we show that there are significant cost savings from consolidation based on standard cost function estimation, we discuss several costs that may arise from consolidation, thus reducing the total possible savings from consolidation. School leaders, the public, and state and local government officials should know the costs and savings from consolidating school districts when discussing school district reorganization.

II. CONCEPTUAL AND EMPIRICAL MODELS

A. Education Production and Costs

Hanushek (1986), Duncombe, Miner, and Ruggiero (1995), and Duncombe, Ruggiero, and Yinger (1996) provide detailed background on the conceptual model for education production and the derivation of school district cost functions. Essentially, any model of education production must link student achievement to school resources and demographic factors.

School output (Y) results from school districts employing various inputs such as teachers and administrators (TA), capital (K), and materials (M). The production process can be represented as:

$$Y = y(TA, K, M) \quad (1)$$

Student achievement (A) is not only a function of school output, but is also a function of environmental factors (E) that impact student achievement. Such factors are family background (F), student characteristics (S), and physical characteristics (P) such as school district size measured by enrollment (N). Implicitly, student achievement (A) is

$$A = a(Y, E) \quad (2)$$

where $E = e(F, S, P)$. Solving the production function in (1) for the implicit cost function for school districts yields $C = c(Y, W, \eta_i)$, where C denotes costs and W represents input prices.

Also, $\eta_i = \mu_i + v_i$ where v_i represents random variation in each district's costs and μ_i is a measure of inefficiency.⁸

Considering output (Y) as a function of achievement gives $Y = y^{-1}(A, E)$. Making this final substitution into the school district cost function yields the modified school district cost function:

$$C = c(y^{-1}(A, e(F, S, P)), W, \eta_i) \quad (3)$$

One issue that arises with empirically estimating (3) is that student achievement (A) and input prices (W) are both determined simultaneously with expenditure decisions. Following Downes and Pogue (1994), a median voter model of education demand can be used to instrument these variables in a simultaneous equation procedure. Variables in an education demand model typically include income, tax rates, local preferences for education quality, and intergovernmental aid.

Scale economies is determined by computing a cost elasticity (ϵ_{CY}) that measures the percentage change in costs per student with respect to a percentage change in student enrollment. Using equation (3), the cost elasticity is:

$$\epsilon_{CY} = \frac{\partial(C/N)}{\partial N} \cdot \frac{\partial N}{(C/N)} = \left(\frac{\partial C}{\partial Y} \cdot \frac{Y}{C} \right) \cdot \left(\frac{\partial Y}{\partial N} \cdot \frac{N}{Y} \right) - 1 \quad (4)$$

Economies (diseconomies) of scale exist if this expression is less than (greater than) zero. A value of zero suggests constant returns to scale. Economies (diseconomies) of scale imply that increasing enrollment will decrease (increase) per pupil expenditures.

B. Data and Empirical Methodology

Our analysis is conducted on 287 school district in Arkansas for the 1999-2000 school year.⁹ All school district data are from the Arkansas Department of Education and the U.S. Census Bureau. Costs (C) are the sum of expenditures on teacher salaries, transportation, and supplies. Average teacher salary serves as our input price (W). We include student enrollment (N) and the square of enrollment to effectively model the U-shaped average cost curve. Both the dropout rate and placement test scores in each district measure student achievement (A). We use ACT (American College Test) scores from the previous year to measure student performance. This test score variable is the average score on the three sections of the ACT test - English, comprehension, and mathematics. Both measures of student achievement are simultaneously determined with expenditure decisions. Student characteristics and family background are measured by the percent of students below the poverty level, the percent of students receiving free lunches, and the percent of adults in the district's county that have a college education.

Our median voter education demand model closely follows that of Downes and Pogue (1994) and Duncombe, Miner, and Ruggiero (1995). We include median household income for each school district's county, state and federal operating aid to each district, the district tax rate on real and personal property, the percent of owner occupied housing, and population.

All variables except those in percentages are transformed to natural logarithms. Descriptive statistics for each variable are shown in Table 1.

[Table 1 about here]

The cost equation (3) can be estimated by OLS with the resulting coefficients used to estimate the cost elasticity in (4).¹⁰ However, OLS fails to account for the simultaneity of both

student achievement and input prices with district expenditures (rendering OLS inconsistent), and it does not account for possible inefficiencies as measured by u_i .

Our estimation procedure is as follows: To account for the endogeneity of student achievement and input prices, these variables are first regressed on a set of instruments that reflect the median voter's demand for education in each school district, as well as all exogenous variables in the cost equation (3).¹¹ The predicted values from these regressions are then substituted into the cost equation (3). This is two-stage least squares (2SLS) without the covariance matrix adjustment. Next, we perform Stochastic Frontier Analysis (SFA) on the cost equation (3) that includes the predicted values for student achievement and teacher input price rather than actual values.¹² Once SFA is done, the covariance matrix is adjusted to arrive at the corrected standard errors for the second stage cost function SFA regressions.¹³

SFA allows estimation of inefficiency by expressing the disturbance term as $\eta_i = \mu_i + v_i$ where v_i represents random variation in each school district's costs outside school district control, and μ_i is a measure of cost inefficiency due to factors such as poor management, low morale, etc. The restriction $\mu_i \geq 0$ reflects the fact that each school district's costs must lie at ($\mu_i = 0$) or above ($\mu_i > 0$) its cost frontier. SFA is implemented using maximum likelihood estimation and provides estimates for σ_v^2 , σ_μ^2 and λ , where $\lambda = \sigma_\mu / \sigma_v$. A σ_v larger than σ_μ ($\lambda < 1$) would suggest substantial variation in the cost frontier across school districts, but relatively little variation of observed costs above the frontier. If σ_v is less than σ_μ ($\lambda > 1$), this would suggest there is little variation in the cost frontier across school districts, but there is relatively more variation in costs above the frontier, or large inefficiencies.

III. RESULTS

Equation (3) is estimated using total costs, teacher salary costs, transportation costs, and supply costs to explore scale differences between the various costs. The cost function estimates are shown in Table 2.¹⁴ The coefficients on enrollment and enrollment squared reflect the U-shaped average cost curves, although the enrollment coefficients in the transportation cost model are not statistically significant at conventional levels. The estimates for λ reveal that, except for transportation costs, the majority of overall model residual is explained by inefficiencies. It appears that there is relatively little variation in cost frontiers across school districts, but there is significant variation in costs above the frontiers.

[Table 2 about here]

The cost elasticity (ϵ_{CY}) for each cost is computed using equation (4) and the mean value for enrollment (1,261).¹⁵ The cost elasticity is:

$$\epsilon_{CY} = \frac{\partial(C/N)}{\partial N} \cdot \frac{\partial N}{(C/N)} = \beta_1 + 2 \cdot \beta_2 \cdot \ln(N) \quad (5)$$

where β_1 and β_2 are the coefficient estimates on enrollment and enrollment squared, respectively. The precision of each cost-elasticity estimate is measured by its standard error.¹⁶

Each cost-elasticity and its standard error are listed in Table 3. With respect to point estimation, all four elasticities reveal economies of scale in the production of education. However, the elasticities for transportation and supply costs have relatively larger standard errors, thus making these estimates less precise (in terms of statistical significance) at the mean level of enrollment than total costs or teacher salary costs.

[Table 3 about here]

The cost elasticities in Table 3 were computed using the mean value of enrollment. While this is the traditional method used to computing elasticities, it is difficult to determine how scale economies change over various ranges of output when relying on an elasticity computed at the mean. If school districts consolidate to experience cost-savings, the elasticities do not provide a clear picture of the cost-savings that school districts of different sizes would experience since the degree of scale economies will certainly differ for enrollment levels above and below the mean. We present the estimated average variable cost curves for each cost in Figure 1 and Figure 2 to provide a general idea of the potential cost-savings from consolidation for different size school districts.

[Figure 1 about here]

[Figure 2 about here]

In accordance with their cost-elasticity estimates, transportation and supply costs clearly decrease with enrollment at a much greater rate than all other costs. In fact, at the mean level of enrollment, transportation and supply costs per student appear to remain constant with respect to enrollment changes, which supports the earlier finding that the transportation and supply elasticities are not statistically different than zero.

Minimum efficient scale (ϵ_{CY} not statistically different than zero at $\alpha = 0.05$) was computed for each cost. Total costs, teacher salary costs, and supply costs reach minimum efficient scale at enrollments of 3,500, 1,850, and 525, respectively. For transportation costs, minimum efficient scale is achieved over all ranges of enrollment. However, it is unlikely that actual transportation costs per student are constant over all ranges of enrollment, but rather the large variation in transportation costs across districts makes any decrease in costs per student at

low enrollment levels (as suggestive by the large cost-elasticity estimate and Figure 2) statistically insignificant. Visual inspection of Figure 2 suggests a minimum efficient scale for transportation costs in the range of 500 to 1,000 students, a result similar to Duncombe, Miner, and Ruggiero (1995).

There is wide variation in minimum efficient scale estimates in the literature. Deller and Rudnicki (1993) found that minimum efficient scale for total costs in Maine school districts occurred at 2,000 students. Duncombe, Miner, and Ruggiero (1995) estimated minimum efficient scale for total costs in New York school districts occurs at 6,500 students, for instructional costs at 1,800 students, and transportation costs at 1,200 students. Riew (1986) found large scale economies exist in Wisconsin school districts up to 1,500 students, and Jacques, Brorsen, and Richter (2000) found scale economies exist up to 1,000 students in Oklahoma school districts. One explanation for the difference in these findings is that several studies reached their conclusions based upon visual inspection of average variable cost curves, whereas others computed cost-elasticity estimates and determined the level of enrollment that generated an elasticity of zero.

IV. COST-SAVINGS FROM CONSOLIDATION - SIMULATION AND DISCUSSION

The empirical findings reveal that significant scale economies exist across Arkansas school districts. While these results are interesting from a purely economic perspective, the results have strong policy implications for many states currently considering school district consolidation. Arizona introduced a bill (SCR 1007, SB1264) to consolidate 222 school districts into 90 districts. In South Carolina, one state legislator introduced a bill (GB 1089) to

consolidate three school districts in one county to a single school district. Also, a recent court ruling by the Arkansas Supreme Court (*Lake View School District vs. Huckabee*; November 21, 2002) states that Arkansas' current system for funding education is inequitable and inadequate, and as such violates the state constitution. The ruling has fostered much discussion regarding the consolidation of school districts in Arkansas.

School district consolidation has several potential benefits and drawbacks. Lower education budgets would free funds for use on other services, thus alleviating some fiscal pressure faced by local governments. School districts could also hire and retain qualified teachers by offering higher wages. Additional training with new educational technology would also be possible. In effect, consolidation would allow more resources to be allocated toward enhancing student performance.

Opponents of consolidation, especially those in rural areas, fear a loss of representation and the closeness of the school districts to the general public since the social fabric of many rural communities is centered on the local school district. Consolidation may increase travel times and reduce student safety as the distance between school and home increases. Opponents argue that the forgone savings from consolidation reflect the value that individual school districts place on autonomy.

Reducing the number of school districts may also give school officials in the remaining districts greater monopoly and agenda-setting power. This is because the weight of each household's education preferences in a larger consolidated school district is a much smaller percentage of the total district preferences than in smaller districts. If each household feels that its opinions are not being heard or acted upon, they may become disheartened and no longer

participate in school district planning. Following Niskanen (1971) and Brennan and Buchanan (1980), it is possible that school officials will exploit this monopoly power for self-interested goals, thereby reducing or negating any cost savings from consolidation.

While the authors recognize the arguments for and against consolidation, this section of the paper provides estimates on the potential cost-savings from hypothetical school district consolidation in Arkansas. We look at the cost-savings for total costs as well as costs for transportation, supplies, and teacher salaries to explore from which expenditure category the bulk of cost savings would come.

We present a consolidation simulation where all of the school districts in a rural county are consolidated into a single school district, in effect giving the respective county one larger school district after consolidation. Our consolidation simulation uses Leslie, Marshall, St. Joe, and Witts Springs school districts in Searcy county, Arkansas. Total enrollment in these districts was 279, 825, 272, and 83, respectively during the 1999-2000 school year. The consolidated school district would have an enrollment of 1,459 students.

All variables in the cost function equation (3) were recalculated using data from the individual districts included in the consolidation. The endogenous input price (W) and student achievement (A) variables were first predicted in the median voter education demand model using the new level of enrollment and the full sample means of all other variables. The fitted values for these three variables for the individual districts were then used to compute respective variables for the consolidated school district. Average teacher salary (W) in the consolidated district is the sum of teacher salary expenditures in each district divided by the total number of FTE teachers in the districts. Test scores for the consolidated district are an average of the test

scores from each individual district.¹⁷ The dropout rate for the consolidated district is the sum of the number of dropouts in each individual district divided by the new level of enrollment. The percent of students below the poverty level and the percent of students receiving free lunches were recalculated in the same manner. Finally, the percent of adults with a college education remains unchanged since this variable is at the county level.

These new variables for the consolidated school district are used with the cost function parameter estimates in Table 2 to predict variable costs and variable costs per unit after consolidation. Standard errors for each prediction are calculated to generate 95 percent confidence intervals for each predicted cost.¹⁸ The simulation results are shown in Table 4.

[Table 4 about here]

Columns 1 and 2 list actual costs and costs per student for each independent school district. Costs and costs per student for the consolidated district are shown in columns 3 and 4. A 95 percent confidence interval for costs per student in the consolidated district is listed in column 5, and the percent in per student cost savings is shown in column 6.

Total per student cost savings from consolidation range from 19.3 to 53.8 percent, with an average cost per student savings of 34.1 percent. Costs per student drop from a four-district average of \$3,155 to \$1,995. In terms of percentages, the largest savings come from transportation costs and supply cost. This finding is contrary to that of Duncombe, Miner, and Ruggiero (1995) who found that transportation costs per student increase beyond 500 students. One caveat with the transportation estimates is that enrollment was not a significant determinant of per student transportation costs, although Figure 2 revealed that transportation costs per student decrease rapidly up to 500 students and continue to decrease at a lesser rate beyond that

point. Therefore, if one takes stock in the results that enrollment does not impact transportation costs per students, then there will be no transportation cost savings from consolidation, but there will be no significant cost per student increases either. However, as noted in Duncombe, Miner and Ruggiero (1995) and argued by consolidation opponents, there may be a significant increase in travel time costs to students and parents after school district consolidation.

Teacher salary expenses are the largest component of total costs. Consolidating school district will save an average of 30.6 percent in per student salary costs, with the largest savings coming from the independent districts with the smallest enrollments. Whether this reduction will come at the expense of teaching jobs is an unresolved issue. Salary savings could come through attrition or early retirement rather than layoffs. Also, the desired student-to-teacher ratio may come at the expense of salary savings. Districts will have to evaluate these issues.

The simulations in Table 4 clearly show that school districts can experience large cost savings from consolidation. In terms of total dollars, the four independent school districts have combined total costs of \$4,004,337 before consolidation, and after consolidation have predicted total costs of \$2,910,705. This is an annual saving of \$1,093,632. If one considers half of Arkansas counties as rural and one assumes a similar cost savings from consolidating districts in these rural counties, then a rough estimate of annual cost savings approaches \$40 million annually. The cost savings could be significant for small rural communities.

While scale estimates reveal significant cost-savings from consolidation, an important issue is that geographical constraints may make the consolidation of rural school districts impracticable. Duncombe, Miner, and Ruggiero (1995) discuss how rural school district consolidation in New York may not result in cost savings because of large distances between

sparsely populated, rural school districts. They argue that cost savings could be obtained by sharing administration and support services rather than consolidating actual school buildings. Their conclusions are based on the findings of decreasing returns to scale in transportation and instructional costs beyond 1,000 students.

We argue that geography should not prevent the consolidation of school districts if there are long run cost savings and public support. Contrary to Duncombe, Miner, and Ruggerio (1995), our results for Arkansas reveal that rural school districts would experience instructional cost savings, as well possible transportation cost savings, from consolidation. Also, if concern arises over the distance between the consolidated school district and rural communities, it may be cost effective in the long run to construct new school that minimize the distance between the new schools and the communities they serve. Bonds and revenue generated from the sale of existing school buildings could be used to finance the project. This may certainly result in a large initial cost increase from consolidation, but significant annual savings from consolidation may result in an overall cost saving from the consolidation of school districts.

There are undoubtedly numerous other consolidation possibilities. The point we wish to make is that local officials and parents should publicly discuss the issue of consolidation and, through the democratic process, come to a consensus as to what they deem best for their communities and children.

V. SUMMARY AND CONCLUSIONS

This paper estimated scale economies for Arkansas school districts. The results are important to both the literature on this subject and to the public policy decision process. We find

that significant scale economies exist in teacher salary costs, supply costs, and total costs. The results are less clear regarding transportation costs. The magnitude of scale economies for Arkansas differs from that found in previous studies, highlighting the importance of analyzing each state separately in order to allow effective policy regarding school district consolidation. The empirical models also revealed large inefficiencies across Arkansas school districts.

This study quantified the cost-savings to public school districts from consolidating. We performed a simulation where four rural school districts in one county are consolidated to a single school district. Standard errors for predicted per student cost savings were computed to generate confidence intervals for the predicted per student cost savings. We find that, on average, the four school rural school districts would experience a 34 percent saving in costs per student.

Consolidation would alleviate some fiscal pressures faced by state and local governments and would free funds for use on other services by reducing education budgets. School districts could also hire and retain qualified teachers by offering higher wages that would be afforded by consolidation, and additional training with new educational technology would also be possible. In effect, consolidation could allow more resources to be allocated toward enhancing student performance. While consolidation would offer cost-savings, it may also generate additional costs, such as a loss of representation and the closeness of the school districts to the general public, increased travel times, and a reduction in student safety as the distance between school and home increases. This study has not addressed these potential costs to consolidation.

The consolidation of school districts is a controversial issue drawing harsh reactions from both opponents and proponents. State and local officials must have solid evidence on the all the

potential cost savings and additional costs of consolidation, in addition to input from parents and educators, in order to make an informed and socially beneficial decision regarding the consolidation of school districts.

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FOOTNOTES

* Marvin “Marty” Dodson III sadly passed away as work on this paper was nearing completion.

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1. See *The Outlook for State and Local Finances: The Dangers of Structural Deficits for the Future of Public Education*, National Education Association, 1998.
2. National Conference of State Legislatures, *State Budget and Tax Actions 2002*.
3. See “Schools Prepare to Slash Budgets,” *The Sacramento Bee*, January 16, 2003 and “With Schools Back in Session, Budgets Cuts Become Reality,” *Minnesota Public Radio News*, September 5, 2002.
4. State expenditure and enrollment figures are from the *Digest of Education Statistics*, 2000, Tables 39, 163, and 164.
5. In terms of total education spending, Arkansas expenditures amounted to \$3.01 billion. This represents 37.2 percent of total state expenditures in Arkansas. This percentage is greater than

the state average of 32.4 percent. The Arkansas figure falls within the seventy-fifth percentile of the distribution.

6. We are making the assumption here that there is a direct correlation between educational expenditures and quality. Ferguson and Ladd (1996) find that instructional spending in Alabama school districts had a large, positive effect on test scores. However, Hanushek (1996) argues there is no relationship between expenditures and student performance. Despite these studies, the impact consolidating school districts might have on student performance has not been adequately addressed in the literature.

7. See Andrews, Duncombe, and Yinger (2002) for a survey of the literature.

8. Ruggiero and Vitaliano (1999) explore the inefficiency of New York public school districts.

9. There are 310 school districts in Arkansas. The school districts in the largest cities were dropped since these districts had enrollment levels significantly greater than all other districts in the state. Five districts (each with enrollment >10,000) in the cities of Little Rock, Fort Smith, and Springdale were dropped. Also, 18 districts were excluded due to incomplete data.

10. The translog cost function has been used to analyze scale economies in other public and private industries such as police departments (Gyimah-Brempong, 1987), public libraries (Deboer, 1992), agriculture (Garrett, 2001), and the electric utility industry (Christensen and Greene, 1976). However, use of the translog cost function assumes that the industry of interest is a cost-minimizer. Hanushek (1986) argues this is not likely for school districts.

11. The endogeneity of teacher salaries, test scores, and the dropout rate was tested by performing a Hausman test on the following hypotheses for each variable: H_0 : there is no correlation between the variable and the cost function error term (the variable in question is

exogenous); or H_1 : there is a correlation between the variable and the cost function error term (the variable in question is endogenous). Test details can be found in Hausman (1978) and Godfrey (1988, chapter 5). The Hausman tests revealed that all three variable are endogenous.

12. See Aigner, Lovell, and Schmidt (1977) and Bauer (1990) for background on Stochastic Frontier Analysis.

13. See Greene (1990, page 624).

14. The first-stage regressions for test scores, the dropout rate, and teacher salaries are not shown here, but will gladly be provided upon request. The instruments used to reflect education demand for the median voter explain each variable quite well. The R^2 from each of the test score, dropout rate, and teacher salary equations is 0.43, 0.20, and 0.90, respectively.

15. Economies of scale is a long-run concept. However, the cost curve where capital is not at the cost minimizing level (as assumed here) is the short-run cost curve. Consequently, the literature misleadingly defines the cost elasticity as a measure of short-run economies of scale.

16. Standard errors for each cost elasticity are calculated as:

$$SE(\epsilon_{CY}) = SE(\beta_1 + 2 \cdot \beta_2 \cdot \ln(N)) = \left[\text{Var}(\beta_1) + \text{Var}(\beta_2) \cdot (2 \cdot \ln(N))^2 + 4 \cdot \text{cov}(\beta_1, \beta_2) \cdot \ln(N) \right]^{0.5}$$

17. We assume test scores are constant (the average of each individual district) after consolidation. However, consolidation would free up resources and allow funds to be used to hire more qualified teachers and purchase new technology that could increase student performance. Since we do not know what test scores would be after consolidation, we simply assume a constant level of test scores in the simulation.

18. The prediction variance (mean prediction) is calculated by $\sigma^2 \mathbf{x}_0' (\mathbf{X}'\mathbf{X})^{-1} \mathbf{x}_0$ where σ^2 is the sum of squared residuals, \mathbf{x}_0 is a (K x 1) vector containing the variable values on which the dependent variable is to be predicted, and \mathbf{X} is the (T x K) data matrix. See Gujarati (1995, page 297)

Abbreviations

2SLS: Two Stage Least Squares

OLS: Ordinary Least Squares

SFA: Stochastic Frontier Analysis

TABLE 1
Descriptive Statistics for Arkansas School Districts

| Variable | Mean | Standard Error | Minimum | Maximum |
|---------------------------------|-----------|----------------|----------|------------|
| Cost Equation | | | | |
| Total Cost Per Student | 2,808.0 | 521.1 | 2,124.9 | 8,464.3 |
| Transportation Cost Per Student | 206.5 | 161.4 | 43.1 | 2,615.5 |
| Teacher Salary Cost Per Student | 2,221.4 | 305.8 | 1,593.5 | 4,432.1 |
| Supplies Cost Per Student | 290.9 | 190.2 | 126.8 | 3,006.2 |
| Enrollment | 1,261.7 | 1,426.1 | 83 | 9002 |
| Teacher Salary | 30,947.6 | 3,056.1 | 22,507.7 | 42,098 |
| Test Score | 19.3 | 1.62 | 14.1 | 23.5 |
| Dropout Rate | 3.76 | 2.45 | 0.0 | 18.5 |
| Percent Poverty | 25.77 | 9.96 | 8.47 | 89.6 |
| Percent Reduced Lunch | 39.66 | 16.3 | 0.0 | 92.8 |
| Percent College | 10.46 | 3.55 | 5.2 | 23.5 |
| Median Voter Model | | | | |
| Median Household Income | 22,590.3 | 3,757.5 | 15,036 | 33,020 |
| Operating Aid | 2,404,964 | 2,584,041 | 44,116 | 15,408,843 |
| Property Tax Rate | 356.03 | 270.0 | 25.0 | 1,730.7 |
| Percent Owner Occupied Housing | 64.04 | 5.43 | 49.3 | 76.6 |
| County Population | 37,741 | 37,770 | 5,657 | 349,236 |

Note: Statistics for all variables are in levels. Number of observations = 287.

TABLE 2
Cost Function Coefficient Estimates

| Variable | Total Variable Costs | Transportation Costs | Teacher Salary Costs | Supply Costs |
|-----------------------|----------------------|----------------------|----------------------|---------------------|
| Constant | -20.737** (10.16) | -61.949* (33.26) | -15.535 (10.99) | -9.240 (23.16) |
| Enrollment | -1.083*** (0.19) | -0.850 (0.58) | -1.007*** (0.21) | -1.625*** (0.39) |
| Enrollment Squared | 0.056*** (0.01) | 0.016 (0.03) | 0.055*** (0.01) | 0.092*** (0.02) |
| Teacher Price | 3.404*** (1.08) | 6.410* (3.72) | 2.881** (1.17) | 2.496 (2.55) |
| Test Scores | -0.685 (0.59) | 1.744 (2.11) | -0.811 (0.56) | -1.570 (1.26) |
| Percent Dropouts | -0.009 (0.03) | -0.071 (0.08) | -0.006 (0.03) | 0.017 (0.06) |
| Percent Poor | 0.003* (0.002) | 0.008 (0.004) | 0.002 (0.002) | 0.002 (0.003) |
| Percent Reduced Lunch | 0.080 (0.19) | 1.655** (0.68) | -0.112 (0.22) | 0.125 (0.43) |
| Percent College | -0.005 (0.003) | -0.007 (0.01) | -0.003 (0.003) | 0.0005 (0.007) |
| σ_u | 0.219 | 0.293 | 0.229 | 0.287 |
| σ_v | 0.037 | 0.339 | 0.043 | 0.195 |
| λ | 5.927*** (1.53) | 0.864*** (0.25) | 5.325*** (1.41) | 1.472*** (0.25) |
| Log Likelihood - 2SLS | 102.5 | -182.3 | 93.5 | -53.3 |
| Log Likelihood SFA | 195.8 | -98.4 | 179.4 | -6.5 |

Note: Dependent variable is the natural logarithm of per student costs. Standard errors in parentheses. All variables except those in percentages are in natural logarithms. The above estimates are from the second-stage Stochastic Frontier regressions. First stage regressions for teacher price, test scores, and percent dropouts are available upon request. Log Likelihood 2SLS is obtained from the 2SLS regressions that do not account for school district inefficiencies. Log Likelihood SFA is obtained from the 2SLS Stochastic Frontier regression that does account for inefficiencies. * denotes significance at 10%, ** at 5%, and *** at 1%.

TABLE 3
Cost Elasticity Estimates

| Cost | Cost Elasticity (ϵ_{CY}) | Standard Error |
|----------------------|-------------------------------------|----------------|
| Total Costs | -0.2798 | 0.089 |
| Transportation Costs | -0.6186 | 0.498 |
| Teacher Salary Costs | -0.2238 | 0.095 |
| Supply Costs | -0.3174 | 0.238 |

Note: Elasticities were computed using equation (4) and the mean value for enrollment.

TABLE 4
The Cost Savings from School District Consolidation

| Costs | As Independent Districts | | As a Consolidated District | | | |
|-----------------------------|--------------------------|------------------------------|----------------------------|--|---|---|
| | Cost (\$) (1) | Cost Per Student (\$) (2) | Estimated Cost (\$) (3) | Estimated Cost Per Student (\$) (4) | 95% Interval for Cost Per Student (\$) (5) | Percent Cost Savings Per Student (%) (6) |
| Transportation Costs | | | | | | |
| Leslie | 111,009 | 398 | | | | 62.8 |
| Marshall | 230,513 | 279 | 215,494 | 148 | (128, 171) | 47.0 |
| St. Joe | 71,807 | 264 | | | | 43.9 |
| Witts Springs | 47,587 | 573 | | | | 74.2 |
| Salary Costs | | | | | | |
| Leslie | 623,973 | 2,237 | | | | 27.3 |
| Marshall | 1,632,770 | 1,979 | 2,373,355 | 1,627 | (1,452, 1,829) | 17.8 |
| St. Joe | 603,781 | 2,220 | | | | 26.7 |
| Witts Springs | 270,092 | 3,254 | | | | 50.0 |
| Supply Costs | | | | | | |
| Leslie | 81,998 | 294 | | | | 45.9 |
| Marshall | 176,221 | 214 | 231,981 | 159 | (138, 183) | 25.7 |
| St. Joe | 113,716 | 418 | | | | 62.0 |
| Witts Springs | 40,864 | 492 | | | | 67.7 |
| Total Costs | | | | | | |
| Leslie | 816,980 | 2,928 | | | | 31.9 |
| Marshall | 2,039,510 | 2,472 | 2,910,705 | 1,995 | (1,788, 2,226) | 19.3 |
| St. Joe | 789,304 | 2,901 | | | | 31.2 |
| Witts Springs | 358,543 | 4,320 | | | | 53.8 |

Note: Original enrollments are 279, 825, 272, and 83 respectively. Enrollment for consolidated district is 1,459. The predictions were originally in natural logarithms, therefore +/- 2 standard errors was computed using the natural logarithm of per student expenditures. These figures were then exponentiated to arrive at the level estimates shown above. Standard errors for per student costs in the consolidated school district are - Transportation: 0.0729, Teacher Salary: 0.0569, Supplies: 0.0692, Total: 0.0547. The percent cost savings in column (6) was computed by dividing column (4) by column (2) and subtracting this quotient from one.

FIGURE 1
Average Cost Curves

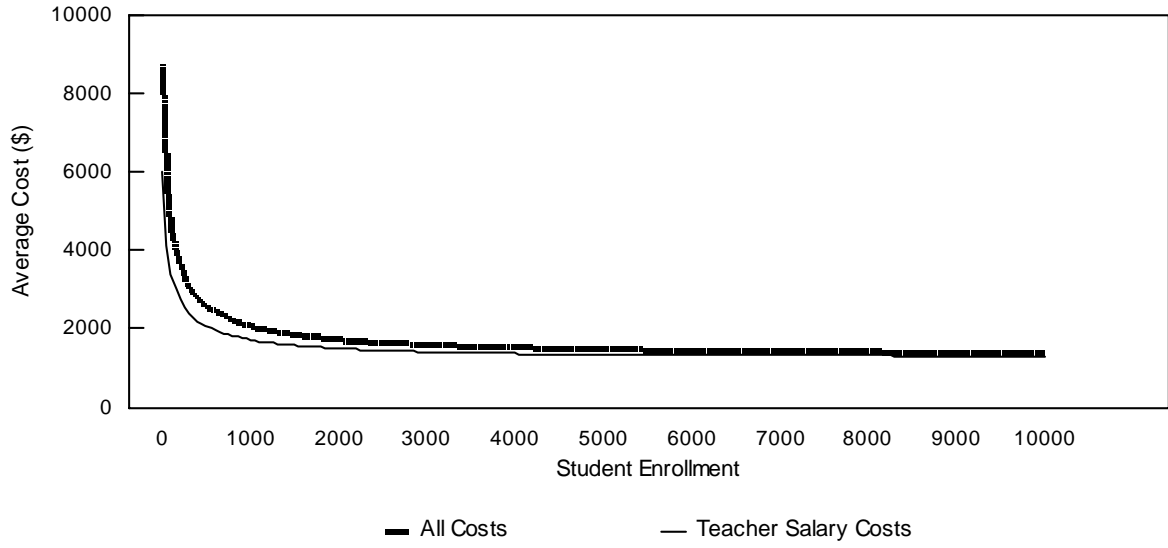


Figure 2
Average Cost Curves

