How Do the Number and Size of School Buildings Affect School District Costs and Student Achievement?

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Abstract

In this paper, we considered the sources of economies of scale and student achievement in Indiana education. Effects of the number of schools per district on cost per pupil and school enrollment on standardized test passing rates were analyzed through economic regression models. Analysis generated a significant positive coefficient on the number of schools per district on cost per pupil. The coefficient of school enrollment on standardized test passing rates was positive contrary to our hypothesis but it was not significant for elementary, middle, or high schools. It was concluded that increases in district and school enrollments could lead to cost savings and better student achievement levels.

Keywords: education, consolidation, student achievement, cost per pupil, schools per district

How do the number and size of school buildings affect school district costs and student achievement?

In 2007, Indiana Governor Mitch Daniels charged former Governor Joseph Kernan and Indiana Supreme Court Chief Justice Randall Shepard with the task of recommending ways to streamline local government. In their report released on December 11, 2007, the Kernan-Shepard Commission recommended to "Reorganize school districts to achieve a minimum student population of 2,000." (Indiana Commission on Local Government Reform, 2007, p. 14). This recommendation has fueled heated conversations over school district consolidation among elected officials, economists, taxpayers, and parents.

It is widely acknowledged that consolidating smaller school districts can lead to cost savings. Since each school must employ administrative, clerical, and maintenance staffs, it is expected that a district's costs would decrease in tandem with a reduction in the number of buildings it operates. After enrollments climb above a certain level though, costs per pupil begin to rise. Despite the clear economic advantages of consolidating smaller districts, many communities are reluctant to reduce the number of schools in their area. Citizens often oppose consolidation out of fear that school buildings that have long been a mainstay in the community will be closed. Further, a common belief exists that students perform better in smaller schools. Voices advocate for smaller schools for reasons including smaller pupil-teacher ratios, higher participation in extracurricular activities, and increased parental participation.

However, the cost savings offered by larger schools may not be the only benefits from consolidation. Resources and specialized course offerings are more readily available in large schools. Large schools typically offer more foreign language and Advanced Placement courses, as well as updated laboratories. Differences in the strengths and weaknesses of small and large schools raise interest in determining whether the added resources of large schools, or the more intimate learning environments in small schools, have a greater impact on student success.

Generally, it is thought that fewer and larger buildings reduce district costs. But, if research found that students enrolled in smaller schools experience enhanced achievement, school officials will be forced to choose between cost savings and enhanced achievement. However, if enrollment in a few large schools does not impede achievement, there could be a solution to the ever-present issue of consolidation of schools.

Literature Review

Research conducted on the controversial topic of school consolidation typically focuses on one of two topics, cost or achievement. Cost studies almost exclusively are conducted with districts as the unit of measure, while achievement is measured at both the district and the school levels. Very few studies concentrate on both cost and student achievement. When both cost and achievement are analyzed, school level data is hardly ever used, likely due to data being unavailable. This paper intends to fill what appears to be a gap in the literature with regards to analyzing cost at the district level and student achievement at the school level.

Through the considerable amount of research completed on the topic of consolidation, a general consensus has developed that as districts grow larger, costs per pupil decline, all else equal. Expenditures per pupil are typically regressed on a group of inputs, socioeconomic factors, and characteristics of districts and schools. Enrollment squared is frequently included to determine if U-shaped average cost curves indicate economies and diseconomies of scale at different enrollment levels. The resulting conclusions most often reflect economies of scale in education with larger districts benefiting from lower costs per pupil (Andrews, Duncombe, and Yinger, 2002; Bickel, Howley, Williams, and Glascock, 2001; Bowles & Bosworth, 2002;

Chakraborty, Biswas & Lewis, 2000; Dodson III & Garrett, 2003; Duncombe, Miner, and Ruggiero, 1995; Kumar, 1983; Stiefel, Berne, Iatarola, and Fruchter, 2000; Zimmer, DeBoer, and Hirth, 2009).

In 2002, Andrews et al. completed a study to determine if a consensus had been reached on school consolidation since the last summarization of the literature by Fox in 1981. Andrews et al. found that the best studies on cost functions found potentially large cost savings by growing district enrollments from 500 students or less to 2000-4000 students. Diseconomies of scale began to appear for districts larger than 15,000 students.

A recent study completed by Zimmer et al. in 2009 found economies of scale in total costs per pupil in slightly larger schools, with an optimal enrollment of 1,942 students, and diseconomies of scale upon a rise in enrollment. In addition, they found that districts with more secondary schools had significantly higher total costs per pupil. This was consistent with the positive effect of the number of high schools on costs also found by Bickel et al. (2001) and Duncombe et al. (1995).

Bowles and Bosworth (2002) and Chakraborty et al. (2000) found similar results by using similar methods. Student outcomes, input prices, and school or district characteristics were used as independent variables to explain per pupil costs through log-linear cost functions. While some specific variables differed, such as Bowles and Bosworth using test scores to measure output while Chakraborty et al. used graduation rates, both studies found economies of scale in costs per pupil. Specifically, Bowles found that a ten percent increase in school size decreases costs per pupil by approximately two percent.

In our literature review, only Howley (2008) found a variable that favored small schools when he studied the costs of constructing small and large high schools. Howley found that smaller schools, ranging from 138 to 600 students, had construction costs per pupil similar to larger schools, with 601 to 999 students. Schools planned for small enrollments were found to be less expensive per pupil than those planned for large enrollments.

This study will focus on the effect of the number of school buildings on district costs. Few studies address this topic. To accommodate for the small number of cost analyses at the school building level, studies that included variables such as schools per district or grade levels per school were reviewed further. Bickel et al. (2001) investigated the costs of education per pupil and found that as enrollment per district is held constant, costs per pupil rises significantly as the number of schools per district rises. Chakraborty et al. (2000) similarly found that expenditures per pupil climbed as high schools per district increased, albeit with weaker levels of significance.

Duncombe et al. (1995) determined that proposed consolidation on paper does not always work in reality. Through economic analysis, they found that large cost savings per pupil could theoretically result from consolidating districts with enrollments smaller than 500 students in New York State. Upon further examination though, most New York districts with less than 500 students were not good candidates for full consolidation due to being sparsely populated and located in rural areas. Reducing per pupil transportation, instructional, and operational costs through full consolidation would therefore be highly improbable for those districts. They suggested that districts could instead achieve cost savings through partial consolidation by sharing administrative and support staff.

When it comes to how school size affects student achievement, researchers almost unanimously agree that increases in school building enrollments decrease achievement. In fact, all but one of the studies reviewed found that smaller schools foster increased student achievement (Bickel et al., 2001; Ferris & West, 2004; Fowler & Walberg Jr., 1991; Friedkin & Necochea, 1988; Haller, 1992; Jones, Toma, and Zimmer, 2008; Lay, 2007; Lindsay, 1982; Pittman & Haughwout, 1987; Walberg & Walberg III, 1994).

Achievement was measured by a variety of variables such as standardized tests, attendance rates, graduation rates, and the likelihood of participation in extra-curricular activities. Achievement was also gauged by more indirect measures that could serve as distractions from a positive learning environment. These variables included student safety, truancy, and pregnancy.

Andrews et al. (2002) also conducted an extensive review on previous production function studies that measured student achievement. Production functions are models of how different levels of inputs affect outputs of educational activities. Average achievement test scores were the most used output variable along with percentage of students passing achievement tests and dropout rates. Pupil-teacher ratios and school size were included as inputs to many of the production function studies. Most studies included some proxy for the quality of teaching, whether that was years of experience, level of teacher education, or teacher salary. They found more consistent results of either constant returns to scale or decreasing returns to scale at the school level compared to the district level. School buildings with higher enrollments had lower student achievement.

Only one study did not find small schools to be the most favorable environment to foster student achievement. Lee and Smith (1997) were the only study examined that found an optimal enrollment. Medium-sized schools, ranging from 600 to 900 students, had the highest levels of student achievement. Schools with less than 300 students were found to have lower achievement.

Data, Methods, and Results

Data were collected for the academic year 2007 to 2008 for 292 public school districts in the State of Indiana. The data were downloaded from the Indiana Department of Education [DOE] website (Indiana Department of Education, 2010). The DOE's website holds data on school revenues and expenditures, achievement measures, demographic values, and socioeconomic factors. Income data were collected from the Internal Revenue Service (U.S. Internal Revenue Service, 2008). Most variables were taken directly from the source, while others were derived through calculations, including suspension/expulsion rates at the school level. Detailed descriptions of the variables used in this study can be found in Appendix A.

Schools and districts were eliminated from the dataset if they possessed certain characteristics. Schools removed were classified as adult educational facilities, career centers, correctional facilities, early-learning facilities, faith-based schools, mental health facilities, preparatory schools, private schools, special education, or vocational centers. After all exclusions were made, 292 school districts with 2,483 schools remained. Since complete data for some schools were not available, the number of schools included in the regressions totaled 1,436.

Least squares (LS) regression models were used to estimate the effects of independent variables upon the dependent variables of cost and achievement. Separate models were created to measure cost and achievement. The cost model was run three times, once for districts of all sizes, once for districts with more than 4,000 students, and once for districts with less than 4,000 students. Three regressions were then conducted on the achievement model, once for each level of schooling: elementary schools (1st-5th grades), middle schools (7th-8th grades), and high schools (9th-12th grades). Grade 6 was excluded due to varying grade configurations of schools in the State of Indiana. Some districts include sixth grade in elementary schools while others include it in middle schools.

Cost Model

Data and methods.

The cost regression model used for this project is similar to the models used by Bowles and Bosworth (2002) and Chakraborty et al. (2000) in that schools per district, input prices, and characteristics of schools and districts, were included as independent variables. The data used for this cost regression model were collected at the district level in an attempt to determine the effect of schools per district on district costs.

The cost of education is measured in this study by general fund expenditures per pupil. Some researchers use total costs per pupil as their dependent variable representing cost. Total costs per pupil were not used in this study to avoid effects of construction occurring in some districts and not others during the 2007-2008 academic year.

Independent variables included in the model to explain general fund expenditures per pupil were schools per district, district enrollment, district enrollment squared, adjusted gross income per individual, percent of pupils eligible for free lunch, percent of district enrollment in grades 7 and 8, percent of district enrollment in grades 10 through 12, pupil-teacher ratio, and average teacher salary. Definitions and descriptive statistics of the variables used in the cost model can be found in Tables 1 and 2 in Appendix A.

First and foremost, we were interested in determining the effect of schools per district on costs per pupil. Intuitively, one would expect districts with more schools to be more costly per pupil than districts with fewer schools, ceteris paribus. Therefore, we hypothesize that schools per district will have a positive effect on costs per pupil. Such a finding would be consistent with the findings of Chakraborty et al. (2000) and Bickel et al. (2001). Confirmation of this hypothesis could lead to recommendations to consolidate schools within districts.

Enrollment and enrollment squared were included to determine if districts in Indiana exhibit the typical U-shaped average cost curve found by many prior studies. This U-shaped curve would predict a negative coefficient on enrollment and a positive coefficient on enrollment squared. This would indicate economies of scale for small enrollments and diseconomies of scale for large enrollments.

Another district characteristic that could define costs per pupil would be the percentage of students enrolled in middle schools and high schools. Zimmer et al., (2009) Bickel et al. (2001), and Duncombe et al. (1995) found secondary schools, particularly high schools to be more costly per pupil. Therefore, it is hypothesized that the percent of enrollment in grades 10-12 will have a positive coefficient. Similarly, we expect the percent of enrollment in grades 7-8 to have a positive coefficient. This is because it is logical to expect that educating students in middle schools would be more costly than educating students in elementary schools. The percent of enrollment in grades 1-6 was left out of the cost model to use as a point of reference.

Two more independent variables that reflect attributes of the district include Average Gross Income [AGI] per individual and the percentage of students eligible for the Federal school lunch program. These variables reflect the socioeconomic status of school districts. Higher AGI per individual is expected to increase costs per pupil. Higher income communities are likely to have more years of education than the average community and they would likely to be willing to pay more if higher costs are associated with greater quality. Chakraborty et al. (2000) and Duncombe et al. (1995) found that higher levels of income led to higher costs per pupil. Larger percentages of students eligible for free lunch indicate districts with higher poverty levels. More resources would be needed to keep schools safe and productive, which would lead to larger costs per pupil.

Lastly, input costs were reflected in our model by average teacher salaries and pupil-teacher ratios. Rising average teacher salaries are expected with rising costs per pupil. It would be expected that districts with more students per teacher would have a lower costs per pupil.

Results.

Results of the cost regression models can be found in Table 3 in Appendix A. When all districts were included in our cost function regression, the number of schools per district did not significantly change costs per pupil. However, when our sample was split into small (enrollments less than 4,000 students) and large (enrollments greater than 4,000 students) districts, the number of schools per district had similar positive effects on costs per pupil with different levels of significance. Since most school districts in Indiana, 220 of 292, have enrollments smaller than 4,000, it is important to note the slight significance of small districts ($p<0.10$) and the sizeable significance of large districts ($p<0.01$). Looking at statistical significance does not fully portray the results of this regression though. Economically, one additional school per district increased costs per pupil by approximately $65 for both small and large districts, all else equal. For the average district in our sample, enrollment of 3,540 students (Table 2, Appendix A), an extra building adds about $230,000 to general fund expenditures, an increase of about one percent.

As is commonly agreed by many researchers and as hypothesized, larger district enrollments significantly decreased costs per pupil in Indiana school districts. The minimum efficient scale was calculated for our cost function through procedures and calculations that can be found in Appendix B. It was found that costs per pupil reached minimum efficient scale at an enrollment of 2,912 using the model with 272 observations. This is within the 2,000-6,000 range cited by Andrews et al. (2002) and is near the minimum enrollment of 2,000 recommended by the Kernan-Shepard Commission in 2007.

As pupil-teacher ratios became larger in all districts and small districts, costs per pupil significantly fell as hypothesized ($p<0.001$). The variable was not significant for the model including districts with enrollments larger than 4,000.

Higher average teacher salaries significantly increased costs per pupil. Costs per pupil in large districts were only slightly influenced by higher average teacher salaries ($p<0.10$). The models with all districts and small districts showed a much more significant result for average teacher salaries ($p<0.001$).

Like Bickel et al. (2001), Duncombe et al. (1995), and Zimmer et al.'s (2009) previous research, we decided to include variables representing the percent of district enrollment in high schools and the percent of district enrollment in middle schools. For districts of all sizes, the percent of seventh and eighth graders significantly changed expenditures per pupil at the 95% level. The models including all districts and only small districts experienced lower costs if they educated more seventh and eighth graders. Conversely, large districts had increased costs per pupil. The high school variable was not significant for any of the regression models.

Socioeconomic factors significantly affected costs per pupil for all districts, regardless of size. Districts with higher percentages of pupils eligible for free lunch had higher costs per pupil for all districts. The free lunch variable was highly significant for all three models ($p<0.001$). Average gross income significantly increased costs per pupil as income rose in the models including small districts and all districts. Perhaps households in small districts have a higher willingness and ability to pay or large district households may not feel as connected to their school districts as do households in small districts.

Achievement model

Data and Methods.

A regression model was created to measure how enrollment affects achievement at the school building level. Separate regressions were created for the three levels of schooling: elementary school (grades 1-5), middle school (grades 7-8), and high school (grades 10-12). This was done to see how achievement of differing age groups are affected by building size and other variables. School building level data was used in these regressions to address the second question of this project: what is the effect of school building size on student achievement?

Achievement can be measured by many variables including standardized test scores, graduation rates, and college attendance rates. All students in grades 3 through 10 are required to take a standardized test named the Indiana Statewide Testing for Educational Progress (ISTEP). The ISTEP assesses students in the subject areas of English/Language Arts, Mathematics, Science, and Social Studies. School level ISTEP performance data is provided as a percent of students in a particular grade that pass both the mathematics and English portions of the ISTEP.

Independent variables included in the achievement models were school enrollment, percent of students eligible for free lunch, pupil-teacher ratio, average teacher salary, suspension/expulsion incidence rate, and percent of students with limited English proficiency. Definitions and descriptive statistics of all achievement variables can be found in Tables 4 through 7 in Appendix A.

The independent variable of greatest interest in the achievement models for this study was school enrollment to measure building size. Almost all research suggests lower rates of achievement in conjunction with higher enrollments. Therefore, we hypothesized that school building enrollments would have a negative effect on ISTEP passing rates.

Class sizes and teacher quality could shape standardized testing rates. Smaller class sizes, measured by pupil-teacher ratios, would intuitively boost performance rates with a presumed increase in teacher-student interactions. Smaller class sizes could also contribute to more positive learning environments. Therefore, we expected a negative coefficient when performance rates were regressed on pupil-teacher ratios. Average teacher salary was used in this study as a proxy for teacher quality and experience. It was expected that teachers of higher caliber, possibly with more teaching experience, would be paid higher salaries and would better educate their students. Higher salaries were then hypothesized to have a positive coefficient when estimating standardized test passing rates through regression.

Suspension/expulsion rates are likely to influence classroom environments and the ability for students to focus on learning. Disruptions and disciplinary problems are expected to depress performance levels not only for students being suspended or expelled, but also for students in the same classes as suspended or expelled students. It is for this reason that suspension/expulsion rates were hypothesized to have a negative coefficient.

Socioeconomic factors often highly influence student achievement levels. To capture socioeconomic status, the percent of students eligible for free lunch and the percent of students with limited English proficiency were used as independent variables. We expected higher levels for both of these variables to lower ISTEP passing rates.

Results.

Results from the achievement regression models can be found in Table 8 of Appendix A. The results were similar for elementary, middle, and high schools.

Two general themes emerged from this set of models focusing on achievement. First and foremost, larger proportions of students eligible for free lunch within a school highly depressed ISTEP passing rates. Free lunch significantly decreased achievement rates at very high levels of significance ($p<0.001$) for elementary, middle, and high schools. Unfortunately, this result shows that it is difficult to overcome the power that socioeconomic factors, such as poverty, have on achievement.

Secondly, passing rates for elementary, middle, and high schools were significantly higher when teachers were paid larger average salaries. The significance of this result for high schools and elementary schools ($p<0.001$) was larger than for middle schools. If higher teacher salaries signal better teachers, then better teachers improve learning.

Two other socioeconomic factors significantly impacted ISTEP passing rates, one positively and one negatively. As expected, higher suspension/expulsion rates decreased passing rates. Younger students were more affected by higher suspension/expulsion rates than high school students. Performance of elementary students was most affected by behaviors that resulted in suspensions or expulsions. This would tend to make sense due to disruptive behaviors perhaps being more of an interruption to the learning process for younger students.

Larger proportions of students with limited English proficiency increased ISTEP passing rates, significantly for high schools and elementary schools. This result is exactly opposite of what we predicted. It would be plausible to expect standardized test scores to be lower if students have difficulty reading or understanding the exams. One possible explanation could be that a student's English skills were only limited to the extent that he or she could still pass the English portion of the exam. Those particular students may not have fluent English, but they could excel at math.

As anticipated, smaller pupil-teacher ratios boosted achievement. This result was only significant for high schools.

Contrary to the results of much existing literature, this study found that large school building enrollments had little effect on ISTEP passing rates. School building size, as measured by enrollment, had positive coefficients for elementary, middle, and high schools. This result was only significant, albeit slightly, for middle schools.

Conclusion

Consolidation will remain to be a hot-button topic as long as state governments continue to fund public education. With budgetary shortfalls occurring in many states across the country, the arguments about school consolidation will likely continue to be heated as governments attempt to make services, like education, more efficient while citizens will still demand a good education for their children while maintaining connections to their traditional schools. If a primary goal of state governments is to educate children at the minimum level of expenditures per pupil, the findings clearly point to consolidation at both the district and school building levels. However, if the goal is to produce high-achieving students while holding expenditures per pupil low, more should be consulted than cost research.

The objective of this study was twofold: to determine how the number of schools per district affect costs per pupil and if larger schools do in fact depress student achievement levels. It was found that having fewer schools per district does decrease costs per pupil, up until the minimum efficient scale enrollment of 2,912 students. Contrary to common beliefs and the arguments of opponents to consolidation, this study found that larger schools do not depress student achievement, as measured by ISTEP passing rates. Perhaps resources and specialized course offerings, such as more foreign language and Advanced Placement courses and updated laboratories, that are more readily available in large schools, have a positive effect on student achievement. By combining these two findings, these results would suggest consolidation of smaller school districts and consolidation within districts to decrease the number of schools per district.

Further research should continue to examine the potential effects of consolidation on costs of education and student achievement. Until a consensus is reached and confirmed, state governments and school boards ought to consult with community members, while carefully considering school and district characteristics, especially levels of income and poverty, before consolidating schools or districts.

Appendix A: Tables of Regression Results

Table 1
Variable definitions, cost model

Cost: Average expenditures from the district's general fund account, per pupil
Schbldg: Number of school buildings within the district
Enroll: Number of students enrolled within the district
$Enroll^2$: Number of students enrolled within the district, squared
Inc: Adjusted gross income per individual as defined by the Internal Revenue Service
Flunch: Percent of pupils eligible for free lunch
Gr7to8pct: Percent of total district enrollment enrolled in 7th and 8th grades
Gr10to12pct: Percent of total district enrollment enrolled in 10th, 11th, and 12th grades
PupilTeach: Pupil per Teacher ratio, total enrollment divided by number of teachers
SalTeach: Average teacher salary

Table 2

Descriptive statistics for Indiana schools and school districts cost model

Variable	Mean	Standard Deviation	Maximum	Minimum
Cost: General Fund Expenditures Per Pupil	6,161.92	675.08	10,477.34	4,812.89
Schbldg: Number of Schools Per District	6.363	7.201	78.000	1.000
Enroll: District Enrollment	3,540	4,376	35,257	154
$Enroll^2$: District Enrollment Squared	31,618,640	108,731,542	1,243,056,049	23,716
Inc: Adjusted Gross Income Per Individual	22,141.17	4,581.60	47,224.50	12,861.60
Flunch: Percent Free Lunch	28.185	12.914	82.000	3.000
Gr7to8pct: Percent of Enrollment in Grades 7-8	15.643	1.487	26.210	0
Gr10to12pct: Percent of Enrollment in Grades 10-12	23.016	2.888	49.351	0
PupilTeach: Pupil Per Teacher Ratio	17.155	2.003	23.094	10.573
SalTeach: Average Teacher Salary	47,309.20	3,501.86	58,632.00	34,783.00

Table 3

Regression results comparing achievement among all districts, districts with enrollment less than 4000, and districts with enrollment greater than 4000

Dependent Variable: General Fund Expenditures Per Pupil

Variable	All districts		Districts with Enroll <4000		Districts with Enroll >4000	
CONSTANT	6166.515	****	6228.089	****	155.002	
	(6.993)		(6.829)		(0.082)	
SCHBLDG	-1.078		69.548	*	62.201	***
	(-0.0.60)		(1.853)		(2.714)	
ENROLL	-0.081	***	-1.107	****	-0.076	**
	(-3.061)		(-5.980)		(-2.157)	
$ENROLL^2$	2.270E-06	***	1.900E-04	****	-1.232E-06	
	(2.779)		(4.987)		(-0.940)	
INCOMEPC	0.019	**	0.020	*	0.018	
	(2.006)		(1.803)		(1.338)	
FLUNCH	24.018	****	22.439	****	30.409	****
	(6.952)		(5.928)		(5.272)	
GR7TO8PCT	-58.358	**	-60.143	**	224.682	**
	(-2.320)		(-2.467)		(2.286)	
GR10TO12PCT	14.000		15.713		-54.481	
	(1.031)		(1.166)		(-1.527)	
PUPILTEACH	-118.805	****	-115.292	****	20.569	
	(-6.813)		(5.995)		(0.607)	
SALTEACH	0.037	****	0.051	****	0.037	*
	(3.841)		(5.142)		(1.683)	
Observations	292		220		72	
R-squared	0.438		0.537		0.621	
F-Statistic	24.414		27.026		11.304	

T-statistics are shown in parentheses.

**** The estimated coefficient is significant at or below the 0.001 level
*** The estimated coefficient is significant at or below the 0.01 level
** The estimated coefficient is significant at or below the 0.05 level
* The estimated coefficient is significant at or below the 0.10 level

Table 4
Variable definitions, achievement model

ISTEP10: Percent of pupils in grade 10 receiving a passing score on both the math and reading portions of the ISTEP
ISTEP8: Percent of pupils in grade 8 receiving a passing score on both the math and reading portions of the ISTEP
ISTEP5: Percent of pupils in grade 5 receiving a passing score on both the math and reading portions of the ISTEP
Enroll (9-12 model): Number of students enrolled in grades 9 through 12 within a school
Enroll (7-8 model): Number of students enrolled in grades 7 and 8 within a school
Enroll (1-5 model): Number of students enrolled in grades 1 through 5 within a school
Flunch: Percent of pupils eligible for free lunch
PupilTeach: Pupil per Teacher ratio, total enrollment divided by number of teachers
Suex: Suspension/Expulsion Rate, Incidents Per 100 Students
LEP Pct: Percent of pupils with limited English proficiency
SalTeach: Average teacher salary

Table 5

Descriptive statistics for Indiana schools and school districts achievement model, enrollment grades 9-12

Variable	Mean	Standard Deviation	Maximum	Minimum
ISTEP10: Percent Passing ISTEP Math and Reading, Grade 10	57.965	15.370	95.000	7.000
Enroll: School Building Enrollment, Grades 9-12	990.131	719.969	4,050.000	60.000
Flunch: Percent Free Lunch	23.323	14.861	74.000	2.000
PupilTeach: Pupil Per Teacher Ratio	18.170	2.707	40.750	9.907
SalTeach: Average Teacher Salary	48,145.63	4,095.83	59,181.00	35,420.00
Suex: Suspension/Expulsion Rate, Incidents Per 100 Students	0.461	0.517	3.821	0
LEPPct: Percent Limited English Proficiency	2.297	3.556	19.397	0

Table 6

Descriptive statistics for Indiana schools and school districts achievement model, enrollment grades 7-8

Variable	Mean	Standard Deviation	Maximum	Minimum
ISTEP8: Percent Passing ISTEP Math and Reading, Grade 8	61.595	15.348	94.000	9.000
Enroll: School Building Enrollment, Grades 7-8	402.463	241.756	1,399.000	0
Flunch: Percent Free Lunch	31.264	19.327	85.000	1.000
PupilTeach: Pupil Per Teacher Ratio	16.906	2.562	26.588	7.760
SalTeach: Average Teacher Salary	47,928.48	4,118.35	58,912.00	34,948.00
Suex: Suspension/Expulsion Rate, Incidents Per 100 Students	0.528	0.533	3.821	0
LEPPct: Percent Limited English Proficiency	3.426	5.428	33.333	0

Table 7

Descriptive statistics for Indiana schools and school districts achievement model, enrollment grades 1-5

Variable	Mean	Standard Deviation	Maximum	Minimum
ISTEP5: Percent Passing ISTEP Math and Reading, Grade 5	65.026	14.817	100.000	3.000
Enroll: School Building Enrollment, Grades 1-5	354.640	139.125	879.000	59.000
Flunch: Percent Free Lunch	39.782	23.317	93.000	1.000
PupilTeach: Pupil Per Teacher Ratio	17.182	2.789	28.818	9.429
SalTeach: Average Teacher Salary	48,695.62	4,204.99	62,745.00	38,066.00
Suex: Suspension/Expulsion Rate, Incidents Per 100 Students	0.121	0.220	1.812	0
LEPPct: Percent Limited English Proficiency	6.803	10.171	85.075	0

Table 8
Regression results comparing achievement among high schools, middle schools, and elementary schools

Dependent Variable: Percent Passing ISTEP+, Both Math and English, Grade 10, 8, 5

Variable	Grade 10		Grade 8		Grade 5	
CONSTANT	66.396	****	71.899	****	65.955	****
	(10.437)		(10.581)		(14.025)	
ENROLL	0.001		0.004	*	0.001	
	(0.720)		(1.881)		(0.331)	
FLUNCH	-0.931	****	-0.635	****	-0.419	****
	(-21.409)		(-16.562)		(-21.575)	
PUPILTEACH	-0.631	***	-0.230		0.198	
	(-3.175)		(-0.982)		(1.321)	
SALTEACH	4.926E-04	****	2.583E-04	**	2.776E-04	****
	(3.603)		(2.029)		(3.402)	
SUEX	-0.971		-2.085	*	-7.728	****
	(-0.848)		(-1.771)		(-4.583)	
LEPPCT	0.411	***	0.122		-0.081	**
	(2.631)		(1.190)		(-2.220)	
Observations	282		348		806	
R-squared	0.724		0.655		0.584	
F-Statistic	120.473		107.869		186.706	

T-statistics are shown in parentheses.

**** The estimated coefficient is significant at or below the 0.001 level
*** The estimated coefficient is significant at or below the 0.01 level
** The estimated coefficient is significant at or below the 0.05 level
* The estimated coefficient is significant at or below the 0.10 level

Appendix B: Procedure to Determine the Minimum Efficient Scale Enrollment

The following procedure was followed to find the Minimum Efficient Scale (MES) enrollment for Indiana school districts.

(1) Cost function

$$Cost = a + b(Schbldg) + c(Enroll) + d(Enroll^2) + e(Inc) + f(Flunch) + g(Gr7to8pct) + h(Gr10to12pct) + i(PupilTeach) + j(SalTeach)$$

(2) Take derivative of the cost function

$$\frac{\partial Cost}{\partial Enroll} = c + 2dEnroll$$

(3) Set partial derivative of the cost function equal to zero to find the minimum of the function.

$$\frac{\partial Cost}{\partial Enroll} = c + 2dEnroll = 0 \qquad Enroll = -\frac{c}{2d}$$

(4) Use the coefficients for Enroll and Enroll^2 from the regression results to solve for Enroll at the minimum of the function.

a. All districts: 292 observations

$$Enroll = -\frac{2.270x10^{-6}}{-0.081} = 17{,}818$$

b. Small districts (Enroll<4,000): 272 observations

$$Enroll = -\frac{1.900x10^{-4}}{-1.107} = 2{,}912$$

c. Large districts (Enroll>4,000): 20 observations

$$Enroll = -\frac{-1.232x10^{-6}}{-0.076} = -30{,}752$$

(5) Result b is within the 2,000-6,000 range cited by Andrews et. al. (2002) and is near the minimum of 2,000 students recommended by the Kernan-Shepard Commission in 2007.

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