School District Size and Student Performance

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Abstract

This article examines the relationship between school district size and the educational performance of its students. Measures of student performance such as standardized test scores and pass rates, End of Course Assessment (ECA) pass rates and Advanced Placement (AP) pass rates are used. Using Indiana school district data, we find that school district size plays a significant role in student performance. Increasing the size of small school districts to around 1,000 students would increase the average student's performance on the SAT by 48 points; biology ECA pass rates by 10 percentage points and ISTEP eighth grade pass rates by 8 percentage points. Increasing the size of school districts to 2,000 students would further increase SAT scores in addition to increasing ACT scores by 0.85 points and pass rates on AP exams by 14.5 percentage points. Student performance on the algebra End of Course Assessment (ECA) and the share of students earning honors diplomas improves in school districts approaching an enrollment level of 4,000 students. Increasing school district size had no statistically significant impact on End of Course Assessments in English.

1 Introduction

This article examines the relationship between the size of a school district and student performance. This issue is important for two reasons. First, previous studies have shown that smaller school districts (fewer than 2,000 students) are inefficient from a cost perspective (Zimmer et al., 2009; Faulk and Hicks, 2011). Second, since inefficiencies of small school districts are a matter of higher per student cost, the smallest school districts are not able to take advantage of the same economies of scale and scope as larger school districts. Thus, small school districts may suffer the well-known duality problem of higher per unit costs and lower per unit quality measures (Fox 1981). As a result, small school districts face resource constrains that can limit program offerings and ultimately student performance as measured by standardized test scores and pass rates, which in turn are likely to affect post-secondary educational opportunities and outcomes.

While the number of school districts in the United States has decreased precipitously over the past century (Table 1), these questions continue to resonate because many states have an unusually high number of small school districts. Nationally, during 2014-15, 70 percent of school districts had enrollment lower than 2,500 students, and 33.6 percent of all districts had enrollment under 600 students (National Center for Education Statistics, 2016).

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Table 1: Number of school districts by year

Year	1967	1972	1977	1982	1987	1992	1997	2002	2007	2012
US	21,782	15,781	15,174	14,851	14,721	14,422	13,726	13,506	13,051	12,880
IL	1,350	1,177	1,063	1,049	1,029	985	944	934	912	905
IN	399	315	307	305	304	294	294	294	293	291
MI	935	647	606	599	590	585	584	580	579	576
OH	710	640	631	669	621	666	666	667	668	668
WI	519	417	410	408	433	440	442	442	441	440

This study extends the literature by evaluating the relationship between school district size and student outcomes. While numerous studies have examined the relationship between *school* size and student academic performance, less research has focused on how *district* size affects student performance. To conduct this study, we test a model of school district performance using measures of student performance such as standardized test scores, performance on End of Course Assessments and Advanced Placement (AP) performance using data from Indiana's school districts. We also explain the transmission mechanism between per student costs and performance.

The remainder of the article is organized as follows. In the next section, we briefly review the literature examining the relationship between school district size and student outcomes. In the third section, we provide information about the organization, size and distribution of Indiana's school districts. The fourth section describes the data used in the analysis and our modeling strategy. The penultimate section discusses our results and the final section discusses conclusions and extensions.

2 Related Literature

Analysis of school or district size on student academic performance has long been part of efforts to evaluate the efficiency and quality of public education. Research in this area focuses on two measures: those that concentrate on educational outcomes such as test scores, attendance rates, graduation and dropout rates among others, and those that examine costs and address issues such as economies of scale.

Few studies have focused on how *district* size affects student performance.[1] Driscoll et al. (2003) examined the impact of the school district as well as school sizes on student academic performance using 1999 data from California schools. The authors evaluate 5,525 schools in 755 districts in California. The advantage of this study is that it examines size effects at three levels: district, school, and class. Their analysis of school district size found that for school districts with more than 40,000 students "district size has a negative effect on student performance, as measured by standardized scores" (Driscoll et al., 2003, p. 199).[2] Indiana's largest school districts (Indianapolis and Fort Wayne) have enrollment of roughly 31,000 students, which is well beneath the problem threshold.

Andrews et al. (2002) examined school consolidation and attempted to come to a consensus on how school and district size affect costs and student performance. They examine 15 cost function studies and 12 production function studies to answer the following questions: do school size and school district size matter and is consolidation generally an effective policy? They conclude,

> ...moderation in district and school size may provide the most efficient combination. Under some

[1] The majority of studies examining *school* size support the idea that students perform better in smaller elementary and middle schools, however the results for high schools provide mixed results. Some studies found that students in smaller high schools demonstrate higher levels of academic achievement, while others either do not find any effect of school size on achievement levels or their results indicate better academic performance for students attending larger high schools (see Driscoll et al. (2003); Mishel and Rothstein (2002); Haveman and Wolfe (1995); Hedges and Greenwald (1996); Hicks and Rusalkina (2003); Jacques and Brorsen (2002); Lee and Smith (1995, 1997); Levin (2001); Marlow (2000). One of the conclusions discussed in Howley (1994) is that students in low socioeconomic communities perform better in small schools, while students from wealthier communities perform better in large schools.

[2] The coefficient for district size was negative and statistically significant at 1% error level for both elementary and middle school, but it was statistically insignificant for high school regression.

> conditions, consolidation of very small rural districts may save money, as long as schools are kept moderate size and transportation times remain reasonable (Andrews et al., 2002, p. 256).

Cost functions used in the research, for the most part, lead to a conclusion that there is an opportunity to save significant administrative and instructional costs when moving from a small district with 500 or fewer students to a larger district with 2,000-4,000 students (Andrews et al., 2002). These authors note that per student costs may also continue to decline until the enrollment reaches approximately 6,000 students, where economies of scale are exhausted (Andrews et al., 2002). Butler and Monk (1985) find a similar U-shaped relationship but that cost functions are different for large and small school districts with smaller districts operating with lower costs for a given level of enrollment.

Two studies which examined costs in Indiana (Zimmer et al., 2009; Faulk and Hicks, 2011) found similar results. Both studies report minimum efficient scale of roughly 2,000 students per district. Zimmer et al. (2009) used a time series cross section (panel) model of school districts with random cross-sectional effects to test a cost function. Because of endogeneity concerns with teacher salary and performance, the authors used a two-stage modeling approach (2SLS) which identified the second stage cost function. They then calculated the traditional U-shaped cost function, reporting that cost minimization occurred at a point estimate of 1,940 students, but a 5 percent confidence interval that extended the range to 2,900 students. Importantly, the per unit cost function declined quickly to the 1,900 range and rose slowly thereafter.

Faulk and Hicks (2011) perform a similar, cross-sectional analysis of school district size and costs across Indiana, using a quadratic cost function to assess non-linear changes to the cost function. They also controlled for other conditions in the school district, such as the share of free and reduced lunch, the reported at-risk mothers, education levels, poverty and income levels. As with Zimmer et al. (2009) they report very rapid reductions in per unit cost for school districts with less than 1,000 students. In this sample of small districts, adding an additional 10 students would reduce the per unit costs by 83 dollars per student across the entire district. At the enrollment levels of under 2,000 students, per unit costs drop by 33.85 per student with the addition of ten pupils. The cost decline is statistically linear in the very small district sample, but flattens at the levels between 1,000 and 2,000 students. As school districts grow in size, the increase in savings slows.

There are many additional studies of individual school size and school performance (Andrews et al., 2002; Bradley and Taylor, 1998; Lee and Smith, 1995; Barnett et al., 2002; Lamdin, 1995; Eberts et al., 1990; Stiefel et al., 2000). Any study of school size and performance must take into account transportation costs to include the impact of bus rides on student performance which is not the focus of this study.

However, the economies of scale and the duality issues are frequently tackled within the context of individual schools. Fox (1981) provided a theoretical explanation for the duality of cost and quality at the school level. This explanation is consistent with the well-known duality theory in production economics. Fox reviewed a number of studies and found optimal numbers of students at individual schools. Extrapolating the high school level results to school district size (with a single high school) yielded an optimal school district size of 2,700 students, which is 50 percent larger than the median school district in Indiana.

Individual school studies also offer insight into the transmission mechanism for scale economies and quality. For example:

> Smaller size implies lower specialization effects, lower performance, and hence less opportunities for the students. These findings suggest that, where possible, policy should be directed towards securing larger school size and thus better performance (Barnett et al., 2002, p. 308)

The literature cited above is mostly empirical and focused on offering insight on the impact of size upon student performance. However, other studies have also identified the transmission mechanism for scale benefits on quality that are applicable to school districts. Duncombe and Yinger (2007) identified five effects of scale that are relevant to this issue:

1. The quality of some education services does not diminish over a wide range of enrollment. For example, central administration - a superintendent and school board and associated staff - may be able to serve a large number of students.

2. Larger school districts may be able to provide specialized services - science labs, computer labs, athletic facilities - at a lower average cost because they provide those services for more students.
3. Larger school districts may be able to employ specialized labor, such as science, math, and technology instructors, and offer more specialized classes.
4. Larger school districts may be able to negotiate price reductions for supplies and equipment by buying in bulk.
5. Larger school districts may be able to implement innovations in curriculum or management at a lower cost.

Each of these transmission mechanisms for cost savings has a dual effect on performance. Lower overhead costs increase per student spending on other activities so that larger school districts may have better facilities and equipment due to lower per student cost. Specialization and shared personnel are possible in larger districts, but face distinct difficulties in smaller ones. Per unit cost savings in contract services, ranging from health care to paper and office supplies are likely in larger districts, and larger districts have less per unit overhead and so may be able to allocate more resources to innovation.

An example may be helpful to illustrate this. In a smaller school district, there may not be a sufficient demand for an AP Calculus teacher, who would typically demand more compensation and require additional education or training to meet AP requirements (Hicks, 2015). Thus, students within a smaller district may not have access to this class. In larger districts, with several schools, sharing of a teacher across two or more schools may be possible. Sharing a teacher across two districts is far less likely due to differences in pay structure, scheduling, or other factors. As a result, a larger school district is more likely to have specialized staff than a smaller district, even if individual schools are the same size.

School district size and student outcomes also matter because of the implications for post-secondary educational outcomes and ultimately the skills available in the U.S. workforce. AP courses are one predictor of preparation for higher education. Studies have shown that AP coursework influences higher senior-year SAT scores (McKillip and Rawls, 2013) and higher ACT composite scores with AP mathematics courses being especially influential (Mo et al., 2011), college admission decisions and the first-year grade point average during college (Shaw et al., 2012) and are associated with higher likelihood of college enrollment (Chajewski et al., 2011), and somewhat higher college science grades (Sadler and Tai, 2007). Ackerman et al. (2013) found that students with more AP-based course credits from high school had higher college graduation rates and completed their college degrees in fewer semesters of study. Yet small school districts offer fewer AP courses. For example, the average number of AP courses offered by small school corporations in Indiana (enrollment below 1,000 students) is 2.69 courses with some schools offering no AP courses and seven AP courses being the most offered by any school corporation of this size. The average AP course enrollment for school corporations of this size was 8.53 students. In contrast, school corporations with enrollment of 2,000 to 2,999 students averaged almost 6 AP courses and average enrollment of 22 students during 2015. The largest school corporations (enrollment of 10,000 or more) averaged 18.5 AP courses. See Devaraj et al. (2017) for details.

A widely cited study by the President's Council of Advisors on Science and Technology (PCAST)'s (2012) projected that approximately 1 million more STEM professionals would be needed over the next decade than the U.S. was producing indicating that domestic supply of STEM workers is likely to be lower than demand, which has focused attention on increasing the number of STEM majors. Many of the STEM majors in college require calculus as a prerequisite for upper level courses. Math readiness has been shown to be a strong predictor of retention within undergraduate engineering programs (Moses et al., 2011). Taking advanced high school math and science courses influences the choice of STEM major and success in engineering programs (Robinson, 2003). Robinson (2003) notes that students who do not take advanced math and science courses during high school are more likely to experience difficulties in the engineering curricula. Tyson (2011) finds that high school calculus grades are the strongest predictor of grades in college physics and calculus courses. Ackerman et al. (2013) found that students receiving course credit for AP calculus were more likely to complete a STEM major in college. Math skills are also a strong predictor of success in economics principles courses, which are gateway courses to all business degrees (Ballard and Johnson, 2004). Small school districts are less likely to offer high school calculus. For example in Indiana, 67 percent of school districts with enrollment below 1,000 students offer a one-semester AP calculus course and none offer a full-year AP calculus course. In contrast, 75.6 percent of school districts with enrollment between 2,000 and 2,999 students, and 100 percent of school districts with enrollment larger than 10,000 students offer a one-semester AP calculus course. See (Devaraj et al., 2017) for details.

These issues motivate a separate analysis that isolates the effect of school district size on measures of student performance. We use data from Indiana to conduct this analysis.

Table 2: Indiana School Districts by Enrollment Level, 2014

2014 Student Enrollment	Number of Districts	Percent of Total
240 to 499	7	2.42%
500 to 999	46	15.92%
1,000 to 1,499	60	20.76%
1,500 to 1,999	44	15.22%
2,000 to 2,999	40	13.84%
3,000 to 4,999	35	12.11%
5,000 to 9,999	35	12.11%
10,000 to 19,999	18	6.23%
20,000 +	4	1.38%
Total	289	100.00%

3 Organization, Size, and Distribution of Indiana School Districts

During 2014 Indiana had 289 school districts with widely varying levels of enrollment.[3] Table 2 shows the number of public school districts by enrollment level in the state. During 2014, 18.3 percent of school districts had enrollment lower than 1,000 students and 54.3 percent of districts had enrollment under 2,000 students.[4] Of the 157 school districts with enrollment lower than 2,000 students, 85 (54.1 percent) had enrollment declines of 100 or more students between 2006 and 2014 indicating that these school districts are becoming smaller. Of the 289 school districts in the state, 139 (48 percent) had enrollment declines over this period.

Figure 1 provides a map of school districts in Indiana by enrollment size. Nearly all of Indiana's small school districts are adjacent to another small school district. The number of school districts in a county also varies widely ranging from 1 to 16. Of the 92 counties in Indiana, 21 contain one school district (Table 3). Lake and Marion Counties contain the most school districts with 16 and 11.

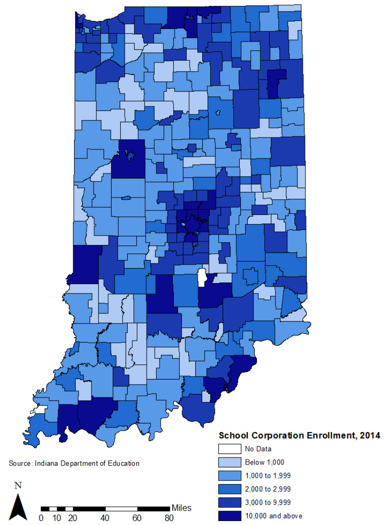
Table 3: Distribution of School Districts by County, 2014

Districts per County	Number of Affected Counties
1 district/county	21 counties
2 district/county	19 counties
3 district/county	22 counties
4 district/county	13 counties
5 district/county	8 counties
6 district/county	4 counties
7 district/county	3 counties
11 district/county	1 county
16 district/county	1 county
Total	92 counties

[3] Charter schools, lab schools, vocational schools and other single schools that the Indiana Department of Education counts as being their own school district are not included in these totals. These represented approximately 130 schools in 2015.

[4] These statistics show an increasing proportion of small school districts. By comparison, in 2012, 17.5 percent of school districts had enrollment lower than 1,000 students and 52.9 percent had enrolment lower than 2,000 students.

Figure 1: Indiana's Public School Districts



4 Empirical Modeling of Student Performance and District Size

To examine student performance, we use 2012-2014 data from Indiana's 289 school districts. We examine performance measures associated with academic achievement and college preparation compiled by the Indiana Commission on Higher Education (2016). To control for non-size-related performance in schools we include demographic heterogeneity measures, the share of students receiving free or reduced lunch and state tuition support per student from the Indiana Department of Education (2016). We include dummy variables describing the location of the school corporation along the rural-urban continuum available from the United States Department of Agriculture (2013). We also include the natural logarithm of number of students taking the SAT and ACT exams in the models examining SAT and ACT scores.[5] Descriptive statistics for the variables used in the analysis appear in Table 4.

Our model is a straightforward exposition of the relationship between scale and educational outcomes (quality), taking the form:

$$Q_{it} = \delta(ln(Z_{it})) + XB + \mu_t + \alpha_i + \epsilon_{it} \quad (1)$$

where the outcome measure, Q, of school district, i, in year t, is a function of the natural log of enrollment, Z, the matrix of control variables X, year fixed effects, μ and error terms containing both district-specific random effects, α and a white noise idiosyncratic error term distributed identically and independently. The outcome measures, Q, includes SAT scores, pass rates for AP exams, end of course assessments for high school students and the state standardized test for fourth and eighth graders (ISTEP). The control variables, X, in the model include share of free and reduced lunch students, share of African American students, and share of Hispanic students, the amount of state tuition support (per student state funding) that each school district received and the number of test takers in the SAT and ACT models. We also include eight categories of USDA's rural-urban continuum code dummies with counties with populations of one million or more as the omitted category. We include year fixed effects to account for unobserved factors such as local economic growth, population growth, and school cohort differences that vary across time common to all school districts and cluster standard errors by school district.

[5]We thank a reviewer for this suggestion.

Table 4: Summary Statistics, 2012-2014

Definition (Source)	Overall				Under 1000		Under 2000		Under 4000		Under 8000	
Dependent Variables	Mean	S.D.	Min	Max	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.
SAT Composite Score among HS grad (ICHE)	971.6	53.5	764.8	1223.2	949.8	43.9	962.1	45.1	968.1	46.3	970.2	49.9
Share of HS grad passing AP exam (ICHE)	0.37	0.22	0	1	0.23	0.22	0.3	0.21	0.33	0.22	0.36	0.22
English ECA Pass Rate among HS grad (ICHE)	0.79	0.09	0.4	0.97	0.79	0.09	0.79	0.08	0.79	0.08	0.79	0.08
Algebra ECA Pass Rate among HS grad (ICHE)	0.72	0.14	0.16	0.98	0.69	0.15	0.71	0.15	0.72	0.14	0.73	0.14
Biology ECA Pass Rate among HS grad (ICHE)	0.45	0.15	0.04	0.96	0.39	0.16	0.42	0.14	0.44	0.14	0.45	0.15
ACT Composite Score among HS grad (ICHE)	21.92	2.08	13	33	21.43	2.19	21.77	2.13	21.91	2.03	21.96	2.04
Share of HS grad with Honors diploma (ICHE)	0.31	0.09	0.04	0.66	0.3	0.09	0.31	0.09	0.31	0.09	0.31	0.09
Share of students passing ISTEP (4th) (IDOE)	0.72	0.14	0.2	0.98	0.71	0.17	0.71	0.15	0.72	0.14	0.72	0.14
Share of students passing ISTEP (8th) (IDOE)	0.63	0.17	0.11	0.95	0.59	0.18	0.62	0.17	0.63	0.16	0.63	0.17
Independent Variables												
Total Enrollment in school district (IDOE)	3477	4242	240	30813	769	196	1243	418	1686	843	2314	1709
Log of Total enrollment in school district	7.71	0.89	5.48	10.34	6.6	0.33	7.06	0.4	7.3	0.53	7.51	0.69
Tuition support per student (IDOE)	5259	599	4569	7686	5446	618	5346	590	5285	574	5265	583
Log of Tuition support per student	8.56	0.11	8.43	8.95	8.6	0.11	8.58	0.11	8.57	0.11	8.56	0.11
Log of number of SAT takers (ICHE)	4.49	0.9	2.4	7.06	3.42	0.32	3.85	0.46	4.1	0.58	4.3	0.73
Log of number of ACT takers (ICHE)	3.11	1.35	0	6.62	1.8	0.84	2.3	1	2.62	1.07	2.85	1.16
Share of free and reduced lunch (IDOE)	0.46	0.15	0.05	0.95	0.46	0.12	0.45	0.12	0.45	0.13	0.45	0.14
Share of African American students in school district (IDOE)	0.04	0.11	0	0.93	0.01	0.01	0.01	0.03	0.01	0.03	0.02	0.07
Share of Hispanic Students in school district (IDOE)	0.07	0.09	0	0.63	0.04	0.05	0.05	0.08	0.05	0.08	0.06	0.09
Counties in metro areas with population >= 1 million* (USDA)	0.34	0.47	0	1	0.13	0.34	0.24	0.43	0.26	0.44	0.31	0.46
Counties in metro areas of 250,000 to 1 million population (USDA)	0.07	0.25	0	1	0.02	0.14	0.04	0.19	0.04	0.2	0.05	0.21
Counties in metro areas with population <250,000 (USDA)	0.14	0.35	0	1	0.16	0.37	0.12	0.33	0.13	0.33	0.14	0.35
Urban population of 20,000 or more, adjacent to a metro area (USDA)	0.08	0.27	0	1	0.1	0.3	0.1	0.29	0.09	0.29	0.09	0.28
Urban population of 20,000 or more, not adjacent to a metro area	0.04	0.2	0	1	0.01	0.11	0.06	0.23	0.05	0.22	0.05	0.21
Urban population of 2,500 to 19,999, adjacent to a metro area (USDA)	0.28	0.45	0	1	0.47	0.5	0.36	0.48	0.35	0.48	0.31	0.46
Urban population of 2,500 to 19,999, not adjacent to a metro area	0.03	0.18	0	1	0.11	0.31	0.05	0.22	0.05	0.21	0.04	0.19
Completely rural, <2,500 urban population, adjacent to a metro area	0.02	0.14	0	1	0	0	0.04	0.19	0.03	0.16	0.02	0.15

* Omitted variable in the model Note: See Table 5 in the appendix for a list of acronyms used in this article.

Spatial dependency is of concern in any study including geography and is treated in two ways. First, we explicitly control for potential spatial dependence across districts by including the three most likely generators of spatial dependence. These appear in our control matrix X, and include measures of income using the share of students receiving free or reduced price lunches, race and countywide measures of rurality (the USDA rural urban continuum code).[6] Since demographics, income and rurality are the most likely source of spatial dependency across school districts, directly including them in the estimation is preferred to assuming spatial autocorrelation of an unknown type.

In Indiana state government funds instructional costs of local school districts through a funding formula.[7] The state tuition support variable included in the model is the amount of per student state funding that each school district received during each year of the study period.[8] The relationship between student funding (and various other inputs) and student achievement has been widely analyzed with mixed results. Hanushek (2003) provides an overview of studies finding that inputs (key resources) are not strongly related to student performance, while Greenwald et al. (1996), for example, provide evidence that resources are positively related to student outcomes.

The panel nature of the analysis is motivated by an interest in accounting for the unobserved heterogeneity across school districts. A cost model, due to very clear theoretical guidance, be estimated in a cross-sectional setting, but performance models lack some of the specification guidance that cost models provide. For that reason, we estimate a panel model using generalized least squares random effects estimation. Because there is not much variation in key variables over the four-year period included in this analysis, random effects model estimates are expected to have much smaller variances than fixed effects estimates making this the preferred modeling strategy Wooldridge (2010). We also perform the Breusch-Pagan Lagrange multiplier (LM) test for all the models with overall sample to test the null hypothesis that variances across school corporations are zero. The LM test results show evidence of statistically significant differences in variance across school corporations, which suggests that random effects model, is appropriate in our setting.

The online appendix contains the entirety of the modeling results, which provide five alternative models to examine changes in educational outcomes as district size changes.[9] In each, we use the natural logarithm of school district enrollment as the size measure. We first measure the impact of enrollment size on the outcome measures across all school districts. We then examine the impact of increasingly larger enrollment sizes (under 1,000 students, under 2,000 students, under 4,000 students and under 8,000 students). Table 5 summarizes the results of these models. Those estimates not meeting the ten-percent level of statistical significance are denoted by zero, while all reported values are statistically significant at the 10-percent level or better using asymptotic t-statistics.

Table 5: Model Results: Impact of increasing school district enrollment

	<1000	<2000	<4000	<8000	Overall
SAT Composite Score for HS students	48.659	62.793	56.581	57.248	50.667
ACT Composite Score	0	0.857	1.21	1.283	1.172
Share passing AP exam among AP students	0	0.145	0.131	0.134	0.116
English ECA Pass Rate among HS students	0	0	0	0	0
Algebra ECA Pass Rate among HS students	0	0	0.033	0.029	0
Biology ECA Pass Rate among HS students	0.104	0.0558	0.0542	0.0523	0.0464
Share of HS students with honors diploma	0	0	0.017	0.0216	0.0234
Overall ISTEP Pass Rate among 4th graders	0	0	0	0.0255	0.0202
Overall ISTEP Pass Rate among 8th graders	0.0837	0.0592	0.0523	0.0441	0.0393

[6] A variety of studies has examined issues related to rural school districts. Howley (1994) provides an overview.

[7] The Indiana funding formula includes a foundation grant which is the same for each student, n honors diploma grant, a special education grant, a career and technical education grant and a complexity grant which is based primarily on the number of students in households receiving TANF, SNAP and foster care.

[8] During 2008 the Indiana General Assembly passed legislation to impose property tax rate caps which significantly limited the ability of many local governments to raise revenue through property taxes. Because this provision substantially lowered local government revenue, the state assumed responsibility for funding some local property tax levies. Most notably, the general fund property tax levy for local school corporations was abolished. School districts still levy property taxes for debt service, capital projects, and transportation, but the state funds instructional costs through a funding formula.

[9] These can be found in online appendix Tables A1 through A9.

These results suggest that there are potential benefits to increasing the size of school districts. Indicators like SAT score and pass rates for End of Course Assessments (ECA) and AP tests provide standardized measures of performance.[10] Our specification of the model allows us to interpret these results as the numeric change on a measure (test score points or share of students) as the size of a school district increases. For the results in Table 5, these figures should be interpreted as the impact to be gained from increasing the size of the school district from the minimum observed level (240 students) to the enrollment level noted in the top row of each column.

With the exception of SAT scores, the biology ECA and the eighth grade ISTEP pass rate, increasing enrollment for the smallest school districts (enrollment ¡ 1,000) to 1,000 students is near zero. This means that increasing enrollment from the smallest observed level to 1,000 students is not sufficient to generate statistically significant impacts on ACT test scores, AP pass rates, English or Algebra ECA pass rates, share of students graduating with an honors diploma or fourth grade ISTEP pass rates.

Scores on college entrance exams and AP exams are affected by enrollment. For SAT scores, significant impacts occur as school districts approach an enrollment level of 1,000 students, continue to increase as enrollment approaches 2,000 students and then dissipate as enrollment continues to increase. Average SAT composite scores are 48 points higher as enrollment approaches 1,000 and then increases an additional 14 points (to 62.7 points) as enrollment continues to increase to 2,000 students.[11] For ACT scores, a significant increase of 0.857 points occurs as enrollment approaches 2,000 students, and scores continue to increase by an additional 0.35 points as enrollment approaches 4,000 and by an additional 0.073 points as enrollment approaches 8,000. As enrollment approaches 2,000 students, AP pass rates increase by 14 percentage points and then dissipate as enrollment increases beyond 2,000. These differences in test scores and pass rates suggest that there are resources differences between small and large school districts.

Statistically significant increases in biology ECA and eighth grade ISTEP pass rates occur as school district size increases from the minimum district size to 1,000 students and then dissipates. Biology ECA pass rates increase by over 10 percentage points and eighth grade ISTEP pass rates increase by over eight percentage points for this level of enrollment. We note here that in the descriptive statistics (Table 4) the average pass rates for the biology ECA is the lowest of the three types of End of Course Assessments reported in the ICHE data, regardless of school district size and that the confidence interval around the average pass rates overlap. While this may be due to the unusual requirement for students to take, but not necessarily pass, this course to graduate from high school, it likely affects the choice of college major and would seem to conflict with the goal of encouraging more STEM majors. The lower portion of students in the smallest school districts who pass the biology ECA would suggest that students from these districts may not have the same level of science preparation as students from larger districts. Differences in the eighth grade ISTEP exam pass rate indicates that school district size affects outcome indicators not only for high school students but also for middle school students.

As school district size approaches 8,000 students the pass rate for the 4th grade ISTEP exam increases. This result suggests that primary student performance is not as affected by school district size as secondary student performance. As school districts approach an enrollment level of 4,000 students, there is a significant increase in Algebra ECA pass rates and the share of students earning honors diplomas. The algebra ECA pass rate increases 3.3 percentage points as district enrollment approaches 4,000 students, while the share of student earning a honors diploma increases 1.7 percentage points.

The positive impacts of enrollment on performance mimic the cost savings discussed in the literature review (Zimmer et al., 2009). In their model, these authors calculate the cost per student of economies of scale of schools. Figure 2 shows the incremental cost savings of enrollment changes along with our model's estimates of the incremental improvement in test scores (average of tests) as a proxy for quality. Combining these two concepts (as in Fox (1981)) we offer a quality measure as the dual of the cost function. As predicted by economic theory the quality function takes the inverse shape of the cost function.

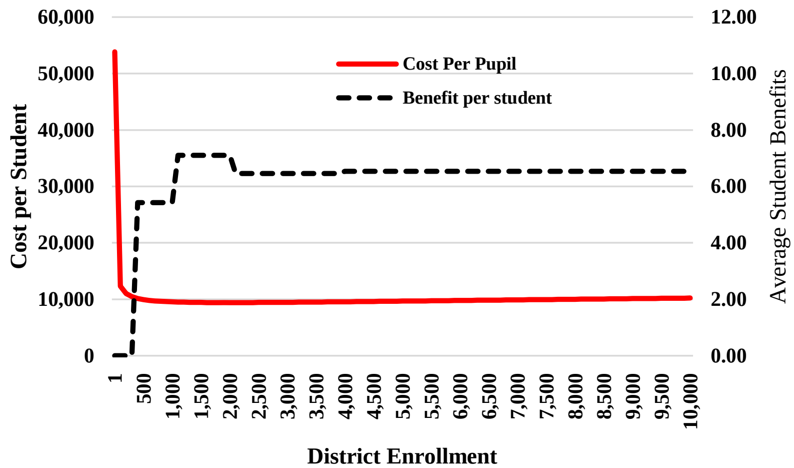
To depict this duality, we show the average, of the incremental change in test scores from our models that depict the increase in scores as school district enrollment increases. The functional improvement in student

[10]The ICHE dataset does not contain information on college graduation rates, time to degree completion or type of degree completed to determine if there are differences in these variables for students from small versus larger school districts.

[11]During this sample period, the SAT was scored out of 2400 points and the ACT was out of 36 points. These tests are an external assessment of college readiness.

performance occurs when increasing district size from the lowest level of enrollment. The biggest gains come between 200 and 2,000 students within a district.[12] We then plot this against the per unit costs of school districts drawn from Zimmer et al. (2009) to illustrate how the large change in per student costs occurs at the very lowest levels of enrollment.

Figure 2: Average Student Benefit and Cost Functions by District Size



The practical point of this analysis is that improvements in both per student costs and per student benefits occur quickly at very low levels of district enrollment. Very small school districts enjoy decreasing costs immediately, as additional students reduce per unit cost due to high fixed costs. We also observe that the benefits from these cost savings accrue quickly to students, and that the largest gains in test scores (from zero to 48 points per student on the combined SAT, for example) occur as school districts of smallest size increase enrollment to approach 1,000 students.

These results suggest that school district size matters. In particular, growing enrollment from the smallest district to roughly 2,000 students is associated with significant gains across many of our measured indicators. Only English ECA pass rates are largely unaffected by scale. Across every other measure, performance increases with school district size. The largest effects of enrollment growth (through consolidation or outright population growth) would be on the pass rates of the AP examinations and SAT composite test scores.

5 Conclusions and Extensions

Previous studies (Zimmer et al., 2009; Faulk and Hicks, 2011) identified significant cost savings available from consolidating Indiana school districts under 2,000 students. School corporations below this size comprise more than 150 out of Indiana's roughly 289 districts. This study extends that research to evaluate the effect school district size plays in the educational outcomes. While this research suggests that there would be benefits to combining school corporations, school district mergers are usually contentious which accounts for the small number of mergers that have occurred in recent years.

Using test scores (SAT, ACT, AP, and ECA) and other measures as proxies for student performance, we find that corporation size plays a significant role in educational outcomes. Increasing the size of small school districts to around 1,000 students would increase the average student's performance on the SAT by 48 points; biology ECA pass rates by 10 percentage points and ISTEP eighth grade pass rates by 8 percentage points. Increasing the size of school districts to 2,000 students would further increase SAT scores in addition to increasing ACT scores by 0.85 points and pass rates on AP exams by 14.5 percentage points. Student performance on the algebra End of Course Assessment (ECA) and the share of students earning honors

[12] In this analysis, we are not able to isolate the exact school district size between the smallest school district and 2,000 students where various outcome measures begin to improve. Previous research suggests that close to 2,000 students is the enrollment level that minimizes costs.

diplomas improves in school districts approaching an enrollment level of 4,000 students. Increasing school district size had no statistically significant impact on End of Course Assessments in English.

When combining costs and performance to evaluate the duality of economies of scale, we find a strong relationship. Cost savings and associated performance improvements are likely to result from increasing the size of smaller school districts. The model results suggest that students attending small school corporations (enrollment $< 2{,}000$ students) face resource constraints that impede secondary school performance, as measured by standardized test scores and pass rates. These constraints are likely to restrict post-secondary educational opportunities and outcomes.

While the data used in this analysis is specific to Indiana, we expect similar outcomes in other states, particularly other Midwestern states, which tend to have relatively large numbers of school districts per county compared to other parts of the country. Future analysis is needed to better quantify these effects among states.

We know of no research that has examined the relationship between school district size and post-secondary outcomes. The results presented here suggest that students from the smallest school corporations do not have the same level of preparation as students from larger corporations, which could affect outcomes such as choice of major, time to graduation, and college graduation rates. Additional research is needed to examine the post-secondary outcomes of students from the nation's smallest school corporations relative to larger corporations.

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Appendix

Table A1: Acronyms

ACT	A standardized test for high school achievement and college admissions
AP	Advanced Placement
ECA	End of Course Assessment
ICHE	Indiana Commission on Higher Education
IDOE	Indiana Department of Education
ISTEP	Indiana Statewide Testing for Educational Progress
SAT	Scholastic Aptitude Test
SNAP	Supplemental Nutrition Assistance Program
STEM	Science, Technology, Engineering and Mathematics
TANF	Temporary Aid to Needy Families
USDA	United States Department of Agriculture