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ABSTRACT

Previous studies found that the small size of schools or school districts mitigated the negative influence of poverty on academic achievement in California, Alaska, and West Virginia. The Matthew Project extends this research in four additional states selected to provide varied settings. Ohio is a very diverse, urbanized state with a large population that nonetheless contains a numerically large rural population. In this report, Ohio data were used in regression equations that predict overall school or district achievement from measures of size, socioeconomic status (SES), and the product of size and SES. These equations illuminate possible "excellence effects" of size by showing which communities (based on SES-level) may benefit or lose from increases in school or district size. Equity effects of size on achievement were also tested by computing the correlation between SES and achievement in groups of larger and smaller schools and districts. Strong evidence was found for both excellence and equity effects of size in Ohio. Across grade levels, smaller schools or districts benefited impoverished communities while larger units benefited more affluent communities. These effects increased in magnitude toward the extremes of SES. Re-analysis by locale found a direct negative effect of school size on achievement in urban and suburban areas and a strong interactive effect of size in rural areas and small towns. Results suggest that some Ohio schools and districts are too large, and in most impoverished communities, schools should be substantially smaller. Appendices include a regression model and statistical data. (Contains 30 references and 15 data tables.) (SV)

The Matthew Project: State Report for Ohio

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The Matthew Project: State Report for Ohio

EXECUTIVE SUMMARY

The Matthew Project, with support from the Rural Challenge Policy Program, investigated the possible academic excellence and equity effects of school and district size in Montana, Georgia, Ohio, and Texas. Previous studies (Friedkin & Necochea, 1988; Howley, 1995, 1996; Huang & Howley, 1993) had reported that the effects of size depended on accounting for the interaction of size and socioeconomic status (SES). The Matthew Project studies build on that line of inquiry.

We constructed equations that predict overall school or district test scores from measures of size, socioeconomic status, and the product of size and socioeconomic status. Appendix A describes the methodology in detail. These (regression) equations provide a view of the possible excellence effects of size because they show which SES levels are likely to benefit from, or conversely, to be harmed from increases in school or district size, and to what extent. Good policy should aim to distribute resources in such a way that students of various SES levels are benefitted to the maximum; such arrangements would, in effect, cultivate a degree of excellence by providing conditions that appear to maximize academic achievement.

We also tested the equity effects of size (on academic achievement) by dividing relevant groups of schools and districts into two equal groups at the median of size. Then we computed the correlation between SES and achievement. Weaker correlations indicate that SES accounts

for less of the variability in achievement, and so indicate a weakening of the bond between these two qualities. Equity in achievement depends on the weakening of this bond; for instance, on *disrupting* or *mitigating* the negative influence of poverty on achievement. This goal reflects that view, for instance, that achievement should be more strongly influenced by such qualities as effort, adequacy of educational funding, and fairly distributed opportunities to learn.

Our *achievement measures* were average percent passing each of the Ohio Proficiency Tests required at grades 4, 6, 9, and 12 in schools and districts (we performed results separately for schools and districts). Our measure of *school size* was average number of students per school grade cohort (which controls for the spurious influence of differing grade-span configurations among schools); our measure of *district size* was total number of students enrolled in the district (virtually all Ohio districts are K-12 districts, so grade-span was not an issue for the district-level analyses in Ohio). For both schools and districts our measure of *SES* was district-level Aid to Dependent Children (ADC) rates, which, among alternative measures, correlated most strongly at all grade levels in schools and districts with our achievement measures.

Strong evidence for *both* an *equity effect of small size* and for an *excellence effect of small size for impoverished communities* exists in Ohio. At all grade levels (4, 6, 9, and 12), for two sorts of achievement measures (regular and advanced "pass rates" on the Ohio Proficiency Tests), and for both schools and districts, the results are quite similar. The excellence effect, in general, strongly suggests that smaller units (i.e., schools and districts) benefit aggregate performance in units serving impoverished communities, whereas larger units benefit aggregate performance in units serving more affluent communities. These differential effects increase in magnitude as SES increases or decreases toward the extremes of the distribution (i.e., "small" and "large" are continuously measured and analyzed on that basis). There some variations in the general pattern, but, interestingly, controls introduced to test the possible effect of differences in class size have no appreciable results on the school-size findings; the reported differential effect of school size is not related to differences in class size.

The overall pattern that confirms the interaction hypothesis is less clearly observed when the "excellence" analysis is re-computed for rural and small-town versus other schools. In the main analysis, the usual pattern is for both a direct effect and an indirect--interactive--effect of size to emerge. In the re-analysis by locale (rural and small-town versus other), we find that the "other" schools (urban and suburban) generally show a direct negative effect of school size, but no interactive effect. On the other hand, among rural and small-town schools we observe a strong indirect (interactive) effect, but no direct effect of school size.

The equity effect is very consistently observed in all analyses: at every grade level, in analyses of both regular and advanced pass rates, and at both school and district levels. Smaller units *substantially reduce* the negative relationship between community poverty and school and district performance. Compared to larger units, this reduction varies between 20% and 70%.

We discovered that schools serving large proportions of African-American students are generally larger than those serving other students, that nearly 80% of such schools are in major urban areas of "very high poverty" (according to the district typology developed and applied by the Ohio Department of Education). This fact probably explains the strong negative effect of school size in our "other" schools (see previous observations). However, in comparing the performance of the smaller Ohio schools to the larger Ohio schools serving this population, the smaller schools consistently show higher test scores.

Finally, since district size has evident excellence and equity effects, we examined the possible correlates of district size. Influences associated with larger size were ADC rates (the higher the rate, the larger the district), percentage of students who are African American (the more such students, the larger the district), and median family income (the higher the income, the larger the district). Influences associated with smaller size were percentage of district property valuation in agricultural property, and local school district income tax rate. Neither rural locale nor percentage of revenue that is locally generated influenced district size at a statistically significant level.

This study suggests that some, perhaps many, schools and districts in Ohio are too large--if maximizing student achievement (excellence) or breaking the negative relationship between poverty and school and district performance is valued by policy makers, citizens, and educators. Some observers have suggested upper limits for school size (e.g., Howley, 1999; Raywid, 1999). Using suggested limits (see "Conclusions and Discussion" for details), we find that 50% of Ohio's elementary schools, 40% of its middle schools, and 30% of its high schools exceed such limits. The Matthew Project findings, of course, suggest that, in the most impoverished communities, appropriate school sizes would be *substantially* smaller. This logic also suggests that school sizes in some quite affluent communities would be too large.

The Matthew Project: State Report for Ohio

Poverty figures as the chief and most prevalent threat to normal academic accomplishment among individuals. If your family is poor, your own odds of succeeding in school lengthen. Your odds are longer still if you attend school with children from many other poor families, which is a likelihood in the U.S., since schools are segregated by social class[1]. In any case, it is certain that affluent communities enjoy decent schools and high-minded pedagogy, whereas impoverished communities continue to "enjoy" shabby schools and a pedagogy of expedience (that is, schooling that is primarily custodial). In fact, one might say that as the threats increase among increasingly impoverished communities, the local resources to counter them diminish *simultaneously*. It seems an especially vicious arrangement.

If, however, some quite ordinary and easily appreciated feature of schooling could be so deployed as to resolve this dilemma more favorably for the children of society's least privileged members, we should applaud it and move to deploy it as seemed advisable. The Matthew Project has pursued a promising line of inquiry relevant to such a hope.

The Matthew Project

The Matthew Project [2] extends previous investigations that found small size to mitigate

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[1]San Francisco recently adopted a plan to integrate its schools on a socioeconomic instead of a racial basis. "Ironically, the fact that economic segregation was never found unconstitutional means that voluntary measures addressed to class are constitutionally permissible" (Kahlenberg, 1999, p. 30-52).

[2]"The Matthew Principle" (Howley, 1995) is the title of the article reporting a study that the current work extends; that previous article is available on the Web at the following URL: <http://olam.ed.asu.edu/epaa/v3n18.html>.

the negative influence of poverty on achievement (in California, Alaska, and West Virginia). In general, the implication from such findings is that the more impoverished the community, the smaller the school or district that would be required to maximize overall student achievement.[3]

This line of inquiry tests the "interaction hypothesis" of school and district size. The interaction hypothesis expresses the possibility that the degree (i.e., strength or weakness) and directionality (positive or negative) of the relationship of size to achievement is contingent on community SES. That is, no one size is "best" or "optimal," because the effects of size hypothetically vary among communities with differing levels of SES.

This is an important insight because so many previous studies have found that the relationship between size and achievement is, in general, small if not insignificant. That research, however, has measured the relationship of size and achievement across all schools and districts. By contrast, the interaction hypothesis suggests that in some places the relationship could be negative and in some places positive; and that, in some places it could be weak, and in some places strong. Further, as a formal and testable hypothesis, it says that this variation could be *systematically associated* with changes some other condition. What might such a condition be? Socioeconomic status (SES) is well known to be the strongest single influence on student achievement, and so it is a logical choice for our "contingent condition."

In informal terms, then, the Matthew Project asks whether or not size is beneficial or harmful to students, and to what extent, in view of community socioeconomic status. Previous

[3]In state after state, legislatures and State Education Agencies (SEAs) have, in myriad laws, regulations, and pronouncements, insisted that teaching students to high standards, and ensuring high levels of student achievement, be the first aim of schooling.

studies in California, Alaska, and West Virginia confirmed such an influence[4].

In the Matthew Project studies, we use school and district performance on state-mandated standardized tests as the measure of achievement. In some states these tests are norm-referenced and in some states they are criterion-referenced (for instance, some states require students to "pass" proficiency tests, and the percent passing in a school or district becomes a gauge of accountability). In any case, in the Matthew Project, schools and districts (not individual students) are the object of study (called "the unit of analysis" in the language of researchers).

The Matthew Project has extended the line of research to include investigations in four additional states: Georgia, Ohio, Montana, and Texas. We selected these states to provide a range of relevant settings to help test the prevalence of the *interaction hypothesis* (the key insight in this line of research) further--a group of states that exhibit variability in the conditions that affect decisions about school and district size. Aside from requiring the availability of suitable data in all states, our selection aimed to provide geographic variety, variety in school district organization (township and whole-county organization), ethnic and racial diversity (both within and between states), and rural and urban diversity (again, within and between states). Table 1 displays this diversity by state.

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[4]Friedkin & Necochea, 1988; Howley, 1995, 1996; Huang & Howley, 1993.

Table 1
Variability in Matthew Project States (Illustrative Data)

	N students (thousands)[1]	N schools[2]	N districts[2]	% minority students[2]	% rural schools[1]	district organization[3]	finance litigation ruling
GA	1,100	1,817	180	44%	21%	county/mixed	constitutional
MT	152	889	457	13%	60%	independent	unconstitutional
OH	1,793	3,841	611	18%	28%	independent[4]	unconstitutional
TX	3,237	7,053	1,042	55%	24%	independent	unconstitutional

Notes:
1. data from Johnson (1989)
2. data from National Center for Education Statistics (1998)
3. Montana maintains elementary, secondary, and K-12 districts.
4. Several of Ohio's poorest districts have been consolidated into county units.

Table 2
Education Resource Allocations by State[1]

	GA	MT	OH	TX
% kids in elementary schools < 350	8	56	24	10
% kids in secondary schools < 900	17	57	49	24
% of schools with class size < 25	64	80	52	90
% schools in need of major repair	26	20	38	27
% **classrooms** with Internet access	35	55	50	42
% **hi pov schools** with net access	87	85	63	79
% all other schools with net access	93	80	81	83
per pupil spending	$4,595	$5,428	$5,438	$4,996
district pp spending disparity[2]	$1,628	$9,171	$5,804	$4,210
education spending ratio[3]	$38	$55	$40	$48
average teacher salary	$35,688	$30,604	$38,833	$35,148
Ed Week Equity Grade	B	B-	C+	D
Ed Week Adequacy Grade	B-	C	B	C+
Ed Week Accountability Grade[4]	A	D	A-	A
Ed Week School Climate Grade[5]	C	B-	D+	C+

Notes.
1. all data from Education Week (1997, 1998)
2. difference between per pupil spending of districts at the 95th and 5th percentiles on spending
3. education spending for every $1,000 of per capita income
4. Education Week "accountability grade" is based on the degree to which states adopt "high standards for all children and assessments aligned with those standards," a perspective that does not enjoy universal support.
5. School climate grades varied from B+ (one state, VT), B (one state, ME) and B- (three states) to D- (three states). 27 states earned grades of C-, C, or C+.

Table 2 presents salient data from comparisons that appeared in *Education Week* special supplements in 1997 and 1998, much of it concurrent with the data analyzed in the Matthew Project state-level reports. The state-level differences apparent in Table 1 are, if anything, magnified by the information in Table 2. Together, Tables 1 and 2 confirm the existence of substantial differences among these four states.

Finally, Table 3 reports widely accessible state-level aggregate scores on National Assessment of Educational Progress proficiency tests administered in 1996 (eighth-grade mathematics) and in 1998 (eighth-grade reading). The performance of students at this grade level is, in a sense, the acid test for school effectiveness (with achievement the touchstone), because their performance shows the accumulated effects of instruction within the state system but before the attrition of school leaving takes its largest toll in high school. Among the three states that participate in this testing program[5] (and, indeed, nationally) Montana has a substantial history of high achievement, as probed by NAEP.

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[5]Ohio no longer participates in the NAEP state-level testing program. However, in the 1992 tests, 59% of Ohio 8th graders scored at or above the basic level in math (Education Week, 1997).

Table 3
National Assessment of Educational Progress Results

	Reading (1998)		Mathematics (1996)	
	% of students testing at or above "basic"	average NAEP score	% of students testing at or above "basic"	average NAEP score
GA	51%	257	51%	263
MT	83%	270	75%	283
OH	---	---	---	---
TX	76%	262	59%	270

Notes: Aggregate NAEP state-level reading scores range from about 230 to 270; aggregate state-level math scores range from about 233 to 284.

Clearly the educational systems differ markedly in these two states--they differ on measures of structure and governance, on measures of resource allocation (processes of the education system), and on outcomes in comparison to one another and to the nation as a whole, according, at least, to the National Assessment of Educational Progress, arguably among the most carefully designed of the various accountability assessment schemes. Those who insist on fashioning "nationally representative" pictures of educational processes will apparently miss a great deal of variation associated with between-state differences.

Educational systems themselves are nonetheless legitimately viewed as parts of larger social systems (e.g., Friedkin & Necochea, 1988; Weber, 1947), that is, in this case, as parts of the political economies of the various states. Most relevant to the Matthew Project, however, are measures of economic equity. Table 4 presents a picture of the prevailing diversity of economic equity in these four states.

Table 4
Selected Economic Equity Indicators by State[1]

	GA	MT	OH	TX
income distribution ratio (rank)[2]	10.9 (40)	7.9 (11)	9.9 (30)	12.2 (44)
rural-urban disparity score (rank)[3]	96 (8)	83 (1)	166 (31)	217 (48)
crime rate (rank)[4]	6301 (45)	4494 (22)	4456 (20)	5709 (38)
sectoral diversity score (rank)[5]	.0445 (11)	.0517 (17)	.0563 (23)	.0548 (21)
dynamic diversity scores (rank)	2.46 (32)	-1.54 (8)	1.71 (29)	2.11 (30)
CED 1998 equity subindex[6]	B (20)	B (13)	C (33)	F (49)

Notes.
1. all data from Clones (1998); numbers in parentheses represent state rankings (lowest number is *most favorable* rank)
2. ratio of earnings of highest income quintile to lowest (see Clones, 1998, pp. 76-77)
3. index of economic disparity between rural and urban areas; the higher the score, the greater the disparity (see Clones, 1998, pp. 76-77)
4. FBI index, serious crimes per 100K population (see Clones, 1998, pp. 78-79)
5. sectoral and dynamic diversity measure (a) diversity of traded industries and (b) similarity of changes in employment among the state's key traded industries (see Clones, 1996, pp. 84-5)
6. The equity subindex is one of three measures comprising the CED "Economic Performance Index"; there are three overall composite indices. The various state grades (GA, MT, OH, and TX) on these are as follows: (1) economic performance (A, C, C, C); (2) business vitality (A, D, C, C); and development capacity (C, B, A, C); see Clones, 1998, pp. 14-19.

Overall, in the view of the CED report (Clones, 1998), Ohio is a middle-ranked state, reflecting its demographic similarity to the nation as a whole. Montana exhibits the most economic equity and Texas the least among these four states; nationally, Alaska ranks first in economic equity and Texas last in the CED report. We do not, of course, trace the exact links between state political-economic contexts in the Matthew Project reports. Still, equity and excellence of achievement are of central concern in our studies, and these concerns relate to the fiscal equity and adequacy of state education systems, and these qualities relate in turn quite clearly relate to conceptions of the manner and form of the distribution of economic goods in society at large. The 50 states vary on all these measures, and so do those examined in these reports.

The extent to which the interaction hypothesis of school and district size appears may well be influenced by such differences as indicated in Tables 1-4. In any case, we believe that studies that attempt to synthesize a national picture of education miss the point that the US maintains a dramatically decentralized system in which longstanding experimentation and local options have evolved quite different state-based systems of schooling. The results of these experiments should be of interest to those who make policy, those who teach, and those who vote. The Matthew Project reports bear witness, we believe, to the importance of state-based educational studies.

Ohio Policy Context (or, Why Ohio?)

Ohio--like Texas and Montana--is among the 15 states[6] whose education finance schemes

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[6]In reverse chronological order: OH (DeRolph v. State, 1997); VT (Brigham v. State, 1996); AZ (Roosevelt Elementary v. Bishop, 1994); MA (McDuffy v. Secretary, Executive Office of Education, 1993); TN (Tennessee Small School Systems v. McWherter, 1993); NJ

have been ruled unconstitutional by state courts (*DeRolph v. State*, 1997). As in Kentucky, Tennessee, and West Virginia, moreover, the press for more equitable funding began with impoverished districts in the Appalachian southeast part of the state. *DeRolph* was decided by a 5-4 split state Supreme Court decision; legislative action following the decision was uniquely pusillanimous.[7] Amid the furor over funding, however, the legislature--without significantly increasing funding--adopted Senate Bill 55, the key component of which, at least in the minds of educators, is the Accountability scheme, which includes report cards based on newly created and mandated proficiency test scores. Funding in Ohio remains inequitable and inadequate (in impoverished districts), and the courts have once again had to insist that the legislature take effective action. About half of Ohio's school funds come from local sources, and approximately one in five (i.e., 118 of 612) districts imposes a school-district income tax.

Like many states organized on the township model, Ohio maintains many small independent districts (612 when the data for this analysis were gathered; now 611). Ohio has a history of maintaining strong local traditions, and citizens' local identities are more strongly attached to towns and townships than to counties (e.g., Guitteau, 1949).

Throughout the 20th century, nonetheless, district reorganization has been a cherished priority among SEAs, with administrative convenience figuring as a prominent motivation. A

(Abbot v. Burker, 1990); KY (Rose v. Council for Better Education, 1989); TX (Edgewood v. Kirby, 1989); MT (Helena Elementary v. State, 1989); AR (DuPree v. Alma School District, 1983); WY (Washakie v. Herschler, 1980); WV (Pauley v. Kelley, 1979); WA (Seattle School District No. 1 v. State, 1978); CT (Horton v. Meskill, 1977); and CA (Serrano v. Priest, 1976). The Kentucky ruling is unique in that it found the entire state system of public schooling--including school finance--unconstitutional.

[7]Instead of acting to improve funding directly, the legislature placed a scheme to provide increased revenues on a statewide referendum. It was defeated by the combined opposition of the litigants themselves, taxpayer groups, and a split professional community. The governor declared a victory, averring that the state had done all it could by providing some new monies, conferring with the electorate, and subsequently continued his career in the US Senate.

Columbia University Teachers College dissertation from 1934 noted that

> every state survey which has been made recently has recommended the elimination, where possible, of extremely small attendance units. The reason given for this policy is that it is more difficult to administer a system of small schools that to administer larger schools caring for the same number of pupils. (Little, 1934, p. 6).

The conventional wisdom applied everywhere, and a 1937 study (Holy & McKnight, 1937) recommended large-scale district reorganization and school closures in each of the state's 88 counties. Of the nearly 1,593 districts operating in 1936-37, these evaluators recommended closing about half; they also advised closing all but 7 of the nearly 1,900 one-teacher schools then existing.[8] Though the literature records successive attempts at promoting rapid district reorganization (Center for Educational Service, 1948; Holy & McKnight, 1937; Purdy & Painter, 1967) by various professional groups, the diminution has proceeded incrementally, rather than dramatically[9]. The Center report ascribes the ineffectiveness of reorganization proposals to a failure of state leadership, but a competing theory would ascribe the cause to a persistent tradition of localism based on functional township units[10].

In virtually all reports during the century, Ohio has claimed a notable rural education problem (units too small to be properly administered; units too small to offer a proper high-school; small units too expensive; and so forth). Today, though Ohio is no longer a rural state, a

[8]In 1900, Ohio maintained 2,402 districts. In 1914 the state maintained 9,489 one-teacher schools, of which 496 were still in operation in 1947, according to the Center for Educational Service (1948) report.

[9]By 1948 Ohio maintained 1,232 districts and in 1967 it maintained 712 (Center for Educational Service, 1948; Purdy & Painter, 1967). Today, as noted in text, 611 district remain.

[10]During the course of writing this section, the author, who lives in southeast Ohio, was visited by a neighbor, a local high school teacher, who was gathering petition signatures to enable him to run for the nonpartisan office of township clerk; residents of this very rural township (a rectangle of approximately 4 miles by 6 miles), located in a mining-dependent county, also elect three township trustees.

large proportion of its smaller schools and districts still constitute a (perceived) rural problem, particularly in the impoverished southeast section of the state, where *DeRolph* originated. Unfortunately, the achievement of fiscal equity, conventionally construed, could be seen by the legislature as requiring, or providing an opportunity for, further district reorganizations and further closures of smaller schools. The professional leadership that has pursued the finance litigation might conceivably find the bargain acceptable at some future date. Certainly the poor condition of Ohio's school facilities is an embarrassment to many professionals. In a zero-sum fiscal game, trading a perceived lesser good for a perceived greater good is the only possibility.

Methods

The Matthew project has conducted a series of studies in which equations relate size of schools or districts, average socioeconomic status of those same schools or districts, and the interaction of size and socioeconomic status[11] in order to predict the aggregate student achievement[12] of schools and districts. That is, the performance of schools and districts--not individual students--was what we sought to predict. These equations all look something like this, and are really quite simple:

size + SES + (size X SES) = achievement

If, in these equations, the interaction term proved statistically significant, we took that fact to mean that the influence of size on achievement varied systematically in tandem with SES. This being the case, we calculated the size of that effect (effect size) using a method pioneered by

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[11]independent variables

[12]dependent variable

Friedkin and Necochea (1988) and applied subsequently in Howley (1995, 1996). The regression model and related procedure are more fully explained in Appendix A. For all equations in this report, we adopted Cronbach's (1987) method of centering independent variables in order to reduce the collinearity of related independent variables--a procedure particularly important in the case of our interaction term[13].

In some cases, we performed additional analyses in order to help draw out the practical implications of findings. One such analysis that we performed for every state concerns an equity effect of small size of schools and districts. These analyses we performed regardless of whether or not the interaction hypothesis was confirmed. One effect of small size, in view of the interaction hypothesis, is that smaller units mitigate the damaging effects of poverty on achievement. That is, "excellence" is more closely approximated when impoverished communities are served by small schools and districts. In this case, it would seem that the small size helps disrupt the usually strong relationship between SES and achievement. This means, that in impoverished communities, excellence is cultivated via an apparent equity effect (that is, breaking the usual bond between SES and achievement). The equity question is whether or not this phenomenon actually pertains to small schools across the board--*regardless of community SES*. In the Matthew Project we tested this possibility by dividing districts and schools at the median of size (the size that divides the small half from the large half) and computing the correlation (Pearson r) between SES and achievement for each half thus defined.

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[13]Collinearity results from strong correlations among independent variables (i.e., size, SES, and interaction terms in this study). Since the interaction term is the product of size and SES, collinearity is a likely event (i.e., either of the factors would be likely to correlate rather highly with the product of both of them). The problem is that collinearity would inflate the error of our measures of the strength of influence (i.e., error associated with the regression coefficients). Centering drastically reduces collinearity; and, in these analyses, has successfully eliminated the problem.

Other analyses that appear in some of the state-level reports investigate the differences between one group or another on various measures, as necessary to help interpret results of the regression equations. In some cases, as well, we introduce control variables (e.g., pupil-teacher ratio) to see whether such additional variables alter the prediction given by our basic model.

Ohio Data

As in all these state analyses, our "sample" was planned to be all the schools and districts in each state. When an entire group, instead of a sample, is used in analyses, the calculation of significance levels is sometimes considered superfluous. The reason is that, since sampling error is not at all an issue (all cases are used, so that estimates for a subgroup are not generalized to the entire group), the observed measurements directly and accurately characterize the prevailing relationships. We have, however, retained the use of significance levels, as we believe that nonsignificant ($p>.05$) relationships, almost by definition, are practically insignificant as well. Therefore, with a few exceptions in this report, we do not provide statistics for equations with nonsignificant relationships for our size variables[14]. Understand, also, that the process of obtaining, cleaning, merging, and analyzing the data inevitably reduces the actual number of cases available for analysis by a small proportion[15]. The number of schools and districts on which we are able to base our results is somewhat less than the total number of districts in the state, but is much larger than a representative sample would be.

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[14]SES may be assumed to be negatively related to achievement in all these analyses; however, cf. the correlations in Table 14.

[15]Missing values on some data and listwise deletion of missing cases (deletion of cases that do not contain values for *all variables* in the analysis) means that the number of cases will also vary from analysis to analysis. We excluded all "special circumstance" districts (n=5), and schools within such districts, from analysis. Special circumstance districts include very small districts on Great Lake islands, for instance; three do not offer high school instruction.

The Ohio Department of Education maintains a web site most useful to researchers; an array of information, including achievement test scores for schools and districts is available at the web site[16]. We downloaded data for the 1995-1996 academic year in November of 1997 and began preparing them for data analysis immediately.

Dependent variables (i.e., achievement test scores). Ohio administers "proficiency tests" in reading, writing, mathematics, citizenship, and science to all students in grades 4, 6, 9 and 12. Scores are aggregated as "percent passing" at the criterion level, which represents the proportion of students in a school or district scoring at or above that level. Correlations between these required tests and other tests (e.g., the California Achievement Test or the Metropolitan Achievement Test) are moderate (Stroud, 1995; Noel, 1994). The SEA data set also shows that passing rates are strongly skewed in most tests, rendering them problematic for the sort of data analysis involved in these studies.

Despite the apparently problematic technical features of these tests, the Ohio Proficiency Tests now universally represent the construct "achievement" to Ohio educators and citizens. To overcome the problem of skewed data, we computed the average of all available tests by grade level for a school or district[17]. The resulting measures proved, as we expected they might, to be normally distributed.

The SEA also reports the percentage of students passing at the "advanced" level. We adopted the same principle of averaging the passing rates of the 4 or 5 applicable tests but found that the resulting composite was still quite skewed. Taking the square root of the test score,

[16]The Ohio SEA web site can be found via the following URL: http://www.ode.ohio.gov/. The availability of achievement data for districts and schools in Ohio was reported by the North Central Regional Educational Laboratory (1996)

[17]For the 1996 administration, grade 9 students did not take a science test.

however, reduced skewness to an acceptable level.

These two sets of test scores--average passing rate (4 grade levels) and advanced passing rate (3 grade levels[18]) became our dependent variables for both school- and district-level analyses.

Independent variables (i.e., size and SES). As with the other studies in this series, our measure of school size was enrollment per grade cohort. This measure helps to control for the possibly confounding effects of school grade-span. That is, a K-6 school of 210 (i.e., 30 students in each of 7 grades) is arguably the same size as a K-8 school (also enrolling 30 students per grade) of 270.

All of Ohio's districts, however, are K-12 districts, so the confounding influence of grade-span is not an issue for the district-level analyses. For these analyses, total district enrollment was our measure of size.

For each of these size measures, however, skewness was evident. To reduce skewness to acceptable levels, we computed the natural log of our size measures. The transformed measures became the size variables.

The Ohio SEA web site did not provide free and reduced price meals data for schools or districts, but did contain district-level rates of families receiving aid to dependent children (ADC rates). The National Center for Education Statistics reported 1994 rates of free-and-reduced-price meals, however. We computed correlations for these two measures and several others[19]; because district-level ADC rates correlated most strongly with our achievement variables, we

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[18]Advanced pass rates were not available for grade 9 in the 1996 data. Students must pass the grade 9 test in order to receive a high school diploma in Ohio.

[19]The additional measures were 1990 district-level census measures (median family income, median housing value, unemployment rate, and so forth) available on the *School District Data Book* (National Center for Education Statistics, 1995).

chose to use them as our measure of SES for both the school- and district-level analyses. As with size, however, ADC rates were skewed, so we computed their natural logarithms as well, and the transformed measure became our SES variable for both the school- and district-level analyses.

Finally, as indicated previously, we centered our variables in order to reduce the risk of collinearity. Consequently, in all analyses reported here, collinearity is not a threat to the results.

Results

We report results in two main sections: (1) regression results and (2) results of correlations between SES and achievement by size halves (the unit divided at the median size). Regression results tell us something about excellence (i.e., the size conditions needed to maximize student achievement), whereas the correlations by size halves tell us something about equity (the strength of the bond between achievement and SES as size conditions vary). Within each section, results are reported first for school-level analyses and second for district-level analyses. The presentation of results concludes with a summary of ancillary analyses. These include (1) introduction of controls for class size to our regression equations, (2) separate regression analyses for schools in rural and small-town districts versus urbanized districts (Ohio SEA district typology), (3) comparison of achievement means in smaller and larger schools serving large proportions of African-American students, and (4) correlates of Ohio district size.

Regressions (schools). We regressed each of the four levels of achievement scores (grades 4, 6, 9, and 12) for both "passing" and "advanced passing" on the pertinent size, SES, and interaction terms (i.e., centered logged cohort size, centered logged ADC rate, and the product of those two centered variables). Table 5 and 6 present the school-level results.

Table 5
Summary of Hierarchical Regression Analysis (School Pass Rates)

Grade Level	Variables in the Equation	B	SE B	β	p	adj R^2	N[a]
4	SIZE	-2.005	.544	-.063	.000	.453	1944
	SES	-9.887	.272	-.727	.000		
	Interaction	-2.254	.433	-.104	.000		
6	SIZE	- .869	.514	-.034	.091	.473	1314
	SES	-10.605	.309	-.697	.000		
	Interaction	-2.723	.419	-.132	.000		
9	SIZE	-4.033	.613	-.183	.000	.432	811
	SES	-6.332	.420	-.498	.000		
	Interaction	-2.680	.480	-.184	.000		
12	SIZE	+2.065	.614	+.114	.001	.371	650
	SES	-6.203	.410	-.572	.000		
	Interaction	- .915	.482	-.073	.058		

Notes. a. listwise N

Table 6
Summary of Hierarchical Regression Analysis (School Advanced Pass Rates)

Grade Level	Variables in the Equation	B	SE B	β	p	adj R^2	N[a]
4	SIZE	- .020	.046	-.008	.660	.445	1943
	SES	- .806	.023	-.710	.000		
	Interaction	- .161	.036	-.161	.000		
6	SIZE	+ .141	.037	+.081	.000	.422	1309
	SES	- .669	.022	-.647	.000		
	Interaction	- .153	.030	-.109	.000		
12	SIZE	+ .223	.047	+.148	.000	.457	650
	SES	- .521	.032	-.580	.000		
	Interaction	- .162	.037	-.156	.000		

Notes. a. listwise N

The results given in Tables 5 and 6 show the existence of a strong interactive effect across grade levels and across the two different sorts of achievement measures. All the observed interaction coefficients are in the expected negative direction, and further, of seven equations, six show a very statistically significant negative interaction effect. Moreover, the direct effect of size (pass rates) is negative in 3 of 4 cases. In Table 6, the direct effect of size is positive for grades 6 and 12, and nonsignificant at grade 4.

Table 7 reports effect sizes (ES) [20] associated with changes in the underlying SES measure (free-and-reduced-price-meal rates), also expressed as a percentile[21]. A positive ES means that the influence of size on achievement at that SES level tends to increase aggregate school-level achievement, whereas a negative ES means that the influence of school size at that SES level tends to decrease aggregate school-level achievement. The larger the number, the stronger the effect, whether negative or positive. The ES's in the various school-level tables (including Table 7) show the change in achievement associated with a change of about 40 students from an average cohort size of about 80 students[22].

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[20]Effect sizes of .20-.30 are considered moderate and practically significant. Effect sizes of .50 and higher are considered quite strong. As a very rough practical guide, one might regard an ES of +1.0 as a comparative improvement of about one year of learning and an ES of -1.0 as a comparative loss of about one year of learning.

[21]Knowing the percentile rank of our SES measure allows readers to judge the extent of the grade 4 effects among Ohio schools. For instance, in Table 7, 50 percent of schools are in districts with ADC rates of 9.25% or higher.

[22]These figures vary among grade levels. At grade 4 the ES represents a change of about 24 students from an average cohort size of about 60 students; at grade 12 the ES represents a change of about 75 students from an average cohort size of about 145 students (anti-log bases).

Table 7
Effect Sizes of School Enrollment on Ohio Proficiency Test Scores for Varying Levels of School SES

SCHOOL SES		EFFECT SIZES BY MODEL						
ADC %-iles	ADC rates	gr 4 pass	gr 6 pass	gr 9 pass	gr 12 pass	gr 4 advanced pass	gr 6 advanced pass	gr 12 advanced pass
0	.00	+.25	+.47	+.35	+.22	+.27	+.47	+.62
10	2.22	+.04	+.15	-.01	+.07	+.09	+.21	+.30
20	3.91	+.00	+.09	-.08	+.04	+.05	+.16	+.24
30	5.39	-.03	+.06	-.12	+.03	+.03	+.13	+.20
40	6.92	-.04	+.03	-.15	+.01	+.02	+.11	+.18
50	9.25	-.06	.00	-.18	.00	.00	+.08	+.15
60	12.54	-.09	-.03	-.22	-.02	-.02	+.05	+.11
70	17.75	-.11	-.07	-.26	-.03	-.04	+.02	+.08
80	26.94	-.14	-.12	-.31	-.05	-.07	-.01	+.03
90	42.50	-.17	-.16	-.37	-.08	-.09	-.05	-.02
100	66.20	-.20	-.21	-.42	-.10	-.12	-.09	-.06

Note. The interaction coefficient for grade 12 pass rates (see Table 5) is marginally significant (p=.058), so we have computed effect sizes for the equation based on the use of population rather than sample data.

The consistency and strength of these school-level is strong evidence that an interaction of SES and school size influences school performance on these tests. Evidence of its operation can be found at all grade levels.

Further evidence of this effect can be inferred from the differing pattern of effects among the models concerned with pass rates (i.e., columns 3-6 in Table 7) and advanced pass rates (i.e., columns 7-9 in Table 7). In the models where advanced pass rates are the dependent variable, the effect of size becomes increasingly positive across the SES spectrum between grades 4 and 12. Even in the most impoverished communities, the negative effect of school size is, in practical terms, practically negligible in the grade 12 column (i.e., -.06). By contrast, in the case of pass rates, the negative effects of school size change from positive to negative at the 50th percentile of ADC rate (i.e., in schools in districts with 10% or more of families receiving ADC). Note, too, that the *negative* effects of size are pronounced at the grade 9 level, the year preceding the dropout year of grade 10, and that, once the dropouts leave, the positive effects of size in grade 12 again range across the upper half of the ADC spectrum.

Impoverished students are not generally (many individual exceptions exist, of course) those who achieve at the highest level in a school; quite the contrary, less impoverished students generally perform better than more impoverished students, regardless of aggregate community SES level. A reasonable inference would predict that the students scoring at advanced pass rates are more affluent than the general population in a particular school. The Matthew Project data for Ohio (and several other states as well) show that increases in school size benefit achievement in more affluent communities. The results do not apply to individuals per se, but to schools and districts in the aggregate. If we accept the reasonable hypothesis that it is the more affluent students in a school who most often score at the "advanced pass" level, then one would predict that even in impoverished communities, those students would be particularly benefitted by larger school size, the very pattern observed in columns 7-8 of Table 7, and the changed sign of the coefficients of size in Table 6.

Regressions (districts). Today virtually all of Ohio's regular school districts serve grades K-12. Actual numbers of cases in the analyses, as previously indicated, exclude "special districts" and those with missing data. As with the school-level regression analyses, we computed (1) four grade-level regression equations for (regular) pass rates and three equations for "advanced pass" rates. Tables 8 and 9 report the results[23].

[23]Ohio has large city districts as well as many small rural and suburban districts. To test the possible effect of these large districts on our results, we excluded the 7 districts with enrollments greater than 15,000 students. Results remained substantially as reported in Tables 8-10, with a single exception: the interaction term for the grade 12 pass rate model (Table 8) becomes statistically significant (p=.013). In the advanced pass rate models, as well, the overall positive effect of size becomes marginally more pronounced. The results in Tables 8-10 appear to apply to all Ohio districts.

Table 8
Summary of Hierarchical Regression Analysis (District Pass Rates)

Grade Level	Variables in the Equation	B	SE B	β	p	adj R^2	N^a
4	SIZE	+ .751	.367	+.061	.041	.498	604
	SES	-6.571	.283	-.681	.000		
	Interaction	-1.767	.279	-.186	.000		
6	SIZE	+1.346	.443	+.085	.002	.558	603
	SES	-9.140	.343	-.736	.000		
	Interaction	-1.815	.338	-.148	.000		
9	SIZE	-1.572	.318	-.137	.000	.565	605
	SES	-5.986	.245	-.668	.000		
	Interaction	-1.812	.241	-.205	.000		
12	SIZE	+2.349	.458	+.165	.000	.412	586
	SES	-7.031	.349	-.646	.000		
	Interaction	- .696	.368	-.060	.059		

Notes. a. listwise N

Table 9
Summary of Hierarchical Regression Analysis (District Advanced Pass Rates)

Grade Level	Variables in the Equation	B	SE B	β	p	adj R^2	N^a
4	SIZE	+ .219	.036	+.191	.000	.437	599
	SES	- .579	.028	-.655	.000		
	Interaction	- .113	.028	-.126	.000		
6	SIZE	+ .174	.043	+.142	.000	.314	596
	SES	- .533	.033	-.559	.000		
	Interaction	- .092	.033	-.096	.005		
12	SIZE	+ .289	.036	+.246	.000	.447	585
	SES	- .579	.027	-.655	.000		
	Interaction	- .085	.030	-.088	.004		

Notes. a. listwise N

As with the school-level results, district level results for Ohio also suggest a strong interaction effect characterizes school district performance, such that smaller district size has practical benefits for more impoverished communities, whereas larger district size has practical benefits for more affluent communities. Table 10 gives the related effect sizes at varying levels of socioeconomic status. The ESs show the effect on achievement for a change of approximately 900 students from an average district enrollment of about 1930 students (anti-log bases)[24].

Table 10
Effect Sizes of District Enrollment on Ohio Proficiency Test Scores for Varying Levels of District SES

DISTRICT SES		EFFECT SIZES BY MODEL						
ADC %-iles	ADC rates	gr 4 (pass)	gr 6 (pass)	gr 9 (pass)	gr 12 (pass)	gr 4 (advanced pass)	gr 6 (advanced pass)	gr 12 (advanced pass)
.00	.00	+.43	+.38	+.27	+.29	+.45	+.34	+.43
10.00	1.71	+.25	+.24	+.07	+.23	+.32	+.24	+.34
20.00	3.01	+.17	+.17	-.01	+.20	+.27	+.20	+.30
30.00	4.29	+.12	+.13	-.07	+.19	+.23	+.17	+.28
40.00	5.66	+.08	+.10	-.11	+.17	+.21	+.15	+.26
50.00	7.04	+.07	+.09	-.13	+.17	+.20	+.15	+.25
60.00	8.55	+.02	+.05	-.18	+.15	+.17	+.12	+.23
70.00	11.38	-.02	+.02	-.22	+.14	+.14	+.10	+.21
80.00	15.01	-.06	-.01	-.27	+.12	+.11	+.08	+.19
90.00	22.70	-.06	-.01	-.27	+.12	+.11	+.08	+.19
100.00	66.20	-.12	-.06	-.33	+.10	+.07	+.05	+.16

Note. The interaction coefficient for grade 12 pass rates (see Table 8) is marginally significant (p=.058), so we have computed effect sizes for the equation based on the use of population rather than sample data; see also, footnote 23.

The effect sizes in Table 10 provide a picture of the influence of district size consistent

[24]The fact that size is logged means that the standard deviation of the logged values refers to intervals of different untransformed values. In fact, an increase of size of one standard deviation of the logged variable refers to an increase in size of about 2,000 students, whereas a decrease of the same magnitude (i.e., one standard deviation) refers to a reduction in district size of about 900 students. This phenomenon applies, as well, to the previously reported school-level results.

with those reported in Table 7. In general, however, one might infer from the SES data in Table 10 that the extremes of district-level poverty are concentrated in a few districts, with the result that the range of actual district ADC rates appears restricted in comparison to the school-level phenomenon (i.e., where district-level rates are used as the SES proxy). Again, the contest between equity and excellence appears in the sign differences of columns 3-6 versus columns 7-9. Larger districts are associated with higher advanced pass rates, overall, with, however, the strongest advantage accruing to more affluent districts. Also, we again see the more pronounced negative effects of size in the grade 9 results. And once again, as well, once the grade 10 and 11 dropouts have left, the influence of size becomes increasingly positive, in fact, showing a positive ES across the entire SES spectrum at the district level.

Critical correlations (schools). The school-level regression equations about which we provide information in Tables 5 -7 relate school size to *levels* of student achievement. Another view of the patterns hypothetically evident in these data, however, concerns the *equity* of achievement.

What might that be? Most people understand inequity in school finance. Some schools receive dramatically less funding than others; frequently schools serving impoverished communities are badly funded and affluent communities are well funded (Kozol, 1991). In simple terms, the source of inequity is economic power, and something akin to SES (call it wealth, given the reliance on property tax revenues to fund schooling) determines the level of school funding. Improvements in financial equity would require better funding of schools serving impoverished communities, that is, such improvements would require that we *break* the link between wealth (or SES) and school finance. Why *should* the rich enjoy the best schools?

Equity in achievement represents the operation of the same law. Which children, in general, enjoy the highest achievement? More affluent children do. Some observers, of course, believe that since affluence and ability correlate well, this state of affairs is actually very fair. Others, however, noting that among the affluent and the impoverished a great range of abilities exist, and that in any walk of life a similarly great range of abilities persists, believe that the low achievement of impoverished children is not nearly so fair as it at first might seem (e.g., Howley, Howley, & Pendarvis, 1995). In this view, public schooling can and should do much more to nurture the learning of all students. As with financial equity, equity in achievement means breaking--or at least substantially mitigating--the prevailing bond between SES and achievement[25].

The possibility of an equity effect is suggested by (1) the strong evidence for the existence of an interaction effect in Ohio and (2) the observed subtle differences in the results of our regression analyses for pass rates as compared to advance pass rates. One way to test the existence of such an effect is to divide Ohio schools into two groups, those below the median size and those above the median size and to calculate, within each group, correlations (Pearson r's) between SES and aggregate school achievement. The square of the correlation (R^2) will give the proportion of variance in achievement accounted for by SES. Comparing the values of R^2 in the smaller versus the larger groups of schools will give us an idea of the degree of mitigation, if any, exhibited by the small schools. Tables 11-14 report information about these relationships in smaller versus larger schools in Ohio.

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[25]In practical terms, one is unlikely to break the bond completely, because the negative effects of poverty can be eliminated only when a society finds them intolerable and actively cultivates the well-being of the poor. Even in the current economic boom, however, such a realization has not overtaken the US, and in general, the gap between the affluent and the impoverished is growing ever wider here. Also, some observers balk when they realize that breaking the bond must apply not just to the poor, *but to the affluent as well.*

Table 11
Grade 4 Achievement, Socioeconomic Status, and School Size in Two Groups of Ohio Schools

		means and correlations				
Size	achievement variable	achievement mean[a]	ADC rate mean	grade 4 enrollment	$r_{y,z}$	$r^2_{y,z}$
larger[b] schools	regular pass	74.5%	16.9%	91.5	-.75***	.56
	advanced pass	9.5%			-.76***	.57
smaller[c] schools	regular pass	73.8%	17.2%	43.3	-.57***	.32
	advanced pass	8.5%			-.55***	.31

Notes. $R^2_{y,z}$ is the variance in y (SES) associated with z (achievement). $R_{y,z}$ is the correlation.

*** => p < .0005 (two-tailed)
[a] average percent passing
[b] n = 971 (pass) 970 (advanced pass)
[c] n = 973 (pass and advanced pass)

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Table 12

Grade 6 Achievement, Socioeconomic Status, and School Size in Two Groups of Ohio Schools

Size	achievement variable	achievement mean[a]	ADC rate mean	grade 6 enrollment	$r_{y,z}$	$r^2_{y,z}$
		means and correlations				
larger[b] schools	regular pass	55.8%	15.1%	143.9	-.77***	.59
	advanced pass	7.2%			-.75***	.56
smaller[c] schools	regular pass	55.3%	15.5%	47.7	-.58***	.33
	advanced pass	6.2%			-.52***	.27

Notes. $R^2_{y,z}$ is the variance in y (SES) associated with z (achievement). $R_{y,z}$ is the correlation.

*** => $p < .0005$ (two-tailed)
[a] average percent passing
[b] n = 657 (pass); 652 (advanced pass)
[c] n = 673 (pass and advanced pass)

Table 13

Grade 9 Achievement, Socioeconomic Status, and School Size in Two Groups of Ohio Schools

Size	achievement variable	achievement mean[a]	ADC rate mean	grade 9 enrollment	$r_{y,z}$	$r^2_{y,z}$
		means and correlations				
larger[b] schools	regular pass	76.7%	15.0%	265.0	-.69***	.47
	advanced pass	NA				
smaller[c] schools	regular pass	82.1%	10.3%	93.0	-.53***	.28
	advanced pass	NA			NA	NA

Notes. $R^2_{y,z}$ is the variance in y (SES) associated with z

(achievement). $R_{y,z}$ is the correlation. Advanced pass rates not available for grade 9.
*** => p < .0005 (two-tailed)
[a] average percent passing
[b] n = 409
[c] n = 402

Table 14
Grade 12 Achievement, Socioeconomic Status, and School Size in Two Groups of Ohio Schools

		means and correlations				
Size	achievement variable	achievement mean[a]	ADC rate mean	grade 12 enrollment	$r_{y,z}$	$r^2_{y,z}$
larger[b] schools	regular pass	64.9%	13.7%	267.6	-.64***	.41
	advanced pass	13.5%			-.74***	.55
smaller[c] schools	regular pass	64.9%	9.3%	89.9	-.56***	.31
	advanced pass	12.7%			-.56***	.31

Notes. $R^2_{y,z}$ is the variance in y (SES) associated with z (achievement). $R_{y,z}$ is the correlation. Advanced pass rates not available for grade 9.

*** => p < .0005 (two-tailed)
[a] average percent passing
[b] n = 325 (pass and advanced pass)
[c] n = 325 (pass and advanced pass)

The results in Tables 11-14 give strong evidence that an equity effect of school size exists among Ohio schools. Depending on grade level and achievement measure, community SES in smaller schools accounts for 25 to 50 percent less of the variance in school performance on the Ohio proficiency tests than it does in larger schools.

Critical correlations (districts). We repeated the correlational analyses for districts, with the results given in Table 15. The results are consistent with those reported in Tables 11-14, with all the observed R^2 values in the smaller districts less than those in the larger districts. With one exception (grade 6 advanced pass rates), the smaller districts mitigate the relationship between SES and achievement, as indicated by comparative R^2 values, by between 70% and 20%.

Table 15
Achievement, Socioeconomic Status, and School Size in Two Groups of Ohio Districts

	means and correlations				
Size	grade level	achievement variable	achievement mean[a]	$r_{y,z}$	$r^2_{y,z}$
larger[b] districts	4	pass	79.0%	-.81***	.66
		advanced pass	3.2%	-.66***	.44
	6	pass	60.0%	-.76***	.58
		advanced pass	2.8%	-.47***	.22
	9	pass	90.2%	-.76***	.57
		advanced pass	NA	NA	NA
	12	pass	66.4%	-.55***	.31
		advanced pass	3.7%	-.60***	.35
smaller[c] districts	4	pass	78.0%	-.45***	.21
		advanced pass	3.0%	-.45***	.20
	6	pass	59.0%	-.52***	.27
		advanced pass	2.7%	-.46***	.21
	9	pass	82.3%	-.42***	.18
		advanced pass	NA	NA	NA
	12	pass	64.7%	-.50***	.25
		advanced pass	3.5%	-.51***	.26

Notes. $R^2_{y,z}$ is the variance in y (SES) associated with z (achievement). $R_{y,z}$ is the correlation.

*** => p < .0005 (two-tailed)
[a] average percent passing
[b] n = 303; mean ADC = 11.2% and mean enrollment = 4,674
[c] n = 304; mean ADC = 8.8% and mean enrollment = 1,122

Additional analyses. We performed several ancillary analyses, which we will summarize here briefly. Because class size has long attracted professional interest as a way to improve schooling (e.g., Glass & Smith, 1979; Finn, 1998), we re-computed our regular and advanced pass regression equations for the school level to include class size[26] as a control variable. No appreciable differences emerged; introduction of the control variable does not render any of the statistically significant interaction terms nonsignificant. In all 7 equations, the observed coefficient of class size appears in the expected positive direction and contributes little or additional explained variance. In 2 of the 4 "regular pass rate" equations (grades 4 and 6), the coefficient of class size is highly significant; the coefficient of class size is statistically significant in 1 of the 3 "advanced pass rate" equations (grade 4, p=.029). In 2 of the 3 cases where class size enters the equation significantly, the direct effect of school size becomes nonsignificant, though the interaction effect persists as highly significant in these cases (grade 6 regular pass rate, grade 4 advanced pass rate). Regression output is displayed in Appendix B.

We also re-computed the regressions for the "regular pass rate" according to whether the districts in which the schools were located were classified by the Ohio SEA as rural or small-town (about 40% of cases) versus others (urbanized, including both very high and very low SES districts, about 60% of cases)[27]. Among the "other" schools, the observed pattern shows (a) a *strongly negative direct effect of school size* and (b) *very weak evidence of an interaction effect*; among the rural and small-town schools, the reverse is true: the *interaction effect* appears quite strong, whereas the *direct effect* of size is nil. Overall, explained variance (R^2) is about twice as

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[26]Here defined as the ratio of Ohio "classified staff" (i.e., professional staff) to total school enrollment.

[27]There are 9 types, as follows: 0=Island, special circumstance (excluded from these analyses); 1=rural, high poverty, low SES; 2=rural, low poverty, low-SES; 3=small town, moderate SES; 4=urban, low SES, very high poverty; 5=urban, moderate SES, average poverty; 6=major urban, very high poverty; 7=urban/suburban, high SES; 8=urban/suburban, very high SES.

large in the "other" schools as compared to the rural and small-town schools.

To further investigate size effects among schools serving high proportions of African Americans, we examined achievement in the 514 urban schools with an African-American enrollment at least one standard deviation above the norm for Ohio schools (i.e., more than 33.6% African American students). These schools have an average district ADC rate of 41.5%, which puts them, as a whole, at the 90th percentile of poverty; the median percentage of African-American students is 65%.

We compared the mean achievement of students in the smaller versus the larger half of Ohio schools, as distributed among this population. Not surprisingly (cf. correlation results), all observed differences favored the smaller schools, and, also not surprisingly, the largest difference--equivalent to an ES of .67 of small versus large schools-- appears at grade 9 (cf. regression results). Finally, it came as no surprise that the distribution of this benefit was quite lopsided: for grade 4, 43% of the schools serving this population are in the small half; for grade 6, 46% are in the small half. However, at grade 9, just 16% of the schools are in the smaller half of Ohio schools, and at grade 12, the figure is just 12%. This phenomenon is clearly an urban problem, because 401 of the 514 schools are located in district type 6, "major urban, very high poverty." Just 8 of these schools are located in district type 8 ("urban/suburban, very high SES").

Finally, we investigated the correlates of school district size. We selected 7 variables from among those in our data set known to relate to size, as follows: ADC rates, school income tax rate, family income, percent of revenue generated from local sources, percent of African-American students, percentage of local valuation generated by agricultural lands, and ruralness[28] and regressed total school district enrollment on them. Five of the 7 variables proved highly

[28](dummy variable, 0=rural, 1=urban

significant ($p<.01$), and 4 of these were very highly significant ($p<.0005$). Neither local revenue not ruralness was a statistically (or practically) significant influence ($p=.158$ and $p=.361$, respectively). The statistically significant positive influences were ADC ($\beta=+.287$), income ($\beta=+.304$), and percent African American ($\beta=+.134$). The greater the poverty, the higher the proportion of African-American students, and the higher the median family income, the larger the district. The statistically significant negative influences were percent agricultural valuation ($\beta=-.440$) and school income tax rate ($\beta=-.089$). The greater the proportion of local valuation in agricultural lands and the higher the school income tax rate, the smaller the district. The equation (adjusted R^2) accounts for 44% of the variation in district size.

Limitations

Some limitations have already been noted in passing. First, our SES measure for schools was not in fact a school-level statistic, but a district-level statistic (i.e., district-level ADC rate). The available school-level statistic[29] did not prove as highly correlated with our achievement as we would have hoped. Measurement of school-level SES is almost always problematic in such studies as this. Choosing the measure that exhibits the highest correlations with our dependent variable, however, helps minimize the likelihood of rejecting a true hypothesis (i.e., Type II error). Second, this is a study of school and district performance, and inferences about individual students are risky. Findings apply to individuals to an unknown degree, if at all. Third, the general phenomenon of interaction, as suggested by our analysis of school performance by Ohio SEA district type, shows that the influence of school size is not uniform. While interaction effects prevail in the generality, the interaction effect best characterizes rural and small-town

[29] 1994 rates of free-and-reduced-price meals, added to our data set from the National Center for Education Statistics *Common Core of Data*.

schools, not "other" (i.e., urban and suburban schools). Among "other" schools, however, a direct negative effect (i.e., applicable equally to all SES levels) is evident[30].

Conclusions and Discussion

The primary aim of this study was to investigate the hypothetical interactive effects of school and district size on aggregate student achievement in Ohio--a sort of differential "excellence effect" of size. A secondary aim concerned testing the hypothetical equity effect of size in disrupting the usual strong negative relationship between SES (meals rate) and achievement.

Interactive effects. We found very strong evidence in Ohio of the existence of the interaction effect of school and district size (see Tables 5-10). The effect was evident for both regular and advanced pass rates, at virtually all grade levels, and for both school and district performance as measured by the Ohio Proficiency Tests administered in 1996. Our ancillary analyses using class size as a control variable provide evidence that the findings are not attributable to variation in school size.

At the same time, it seems reasonable to conclude that the interaction effect of school size pertains most strongly to rural and small-town, as compared to other urban and suburban schools. In rural and small town schools, there seems to be no practically meaningful direct effect of size, *only an interaction effect*. In urban and suburban schools, however, there seems to be no practically significant interaction effect of size, *only a direct (negative) effect* of size.

Equity effects. As in all other analyses we have performed (Bickel, 1999a, 1999b;

[30]One might further hypothesize that this direct negative effect is most salient to urban schools enrolling large numbers of impoverished African American students. We have not, however, performed the analyses to test this hypothesis.

Howley 1999, 1996, 1995; Huang & Howley, 1993), the analyses for Ohio show a strong equity effect of small size. At all grade levels, and at both the district and school levels, and for both regular and advanced pass rates, the association between SES and aggregate student achievement is substantially weakened in smaller units. The mitigating effect of smaller as compared to larger units ranges from 20% to as high as 70%. The effect of maintaining small schools could be seen as equivalent--so far as school performance is concerned--to providing a substantial income boost to impoverished communities.

Final observations. Ohio is a very diverse, urbanized state with a large population that nonetheless contains a numerically large rural population (i.e., in comparison with preponderantly rural states). Demographically, the state resembles the nation as a whole and is often, for that reason, used as a testbed for national marketing campaigns. Confirmation of the interaction hypothesis of size in Ohio is therefore perhaps suggestive of its prevalence at a national level. Nonetheless, our ancillary analyses show that the very diversity of the state renders such generalizations somewhat risky to distinct subpopulations. The interaction phenomenon is more evidently a rural than an urban one in Ohio.[31]

Whether the effect of size is evenly or differentially negative, however, it is clear that many Ohio schools are so large that, on the evidence of this study, they are likely to depress aggregate achievement in them. It is also clear that smaller units break the bond between community SES and aggregate school and district performance. The challenge for educators, policymakers, and citizens is to maintain small units appropriately. Some schools and districts in Ohio may be too small to maximize the achievement of the comparatively affluent students who

[31]But compare Friedkin & Necochea's (1988) metropolitan versus nonmetropolitan comparisons. The metro-nonmetro distinction refers to counties rather than districts, however, and tends to confound rural and suburban locale more than the Ohio SEA typology, which instead confounds urban and suburban settings.

attend them. On the other hand, it is clear that many urban Ohio students attend schools much too large to serve them well; this burden is more onerous still when it falls disproportionately on African-American students and communities.

I have elsewhere suggested and illustrated a logic for establishing upper limits for *school* size (Howley, 1997). If these suggested limits are applied to schools in Ohio, approximately 30% of high schools, 40% of middle schools, and 50% of elementary schools to exceed the limits derived from this logic.[32] For Montana, a state that maintains many small schools and districts, and where the interaction hypothesis receives only weak support, the comparable results were 8%, 4%, and 7%.

I cannot, of course, maintain that my suggested limits are the best, the most sensible, or the most logical. This example, however, shows that such considerations can establish benchmarks capable of revealing striking differences that should provoke some debate about states' policies on school and district size, in light of results such as those reported in the Matthew Project studies.

[32]The logic derives from the fact that elite private schools enroll about 1,000 students in grades 9-12, taken as the upper limit based on the notion that a school this large is most suitable for the most affluent community. Upper limits for common grade configurations in Ohio based on Howley (1997) are: 9-12 (1,000); 6-8 (600); and K-6 (400). The most common middle-level configuration in Montana is 7-8 rather than 6-8, so 400 students would be the hypothetical upper limit. I have not suggested upper limits for district size, however.

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APPENDIX A

Note on Method

This study employs a very simple regression model, with an interesting methodological innovation. The model was developed and applied by Noah Friedkin and Juan Necochea (1988) to a California data set. The study is widely cited in the school size literature. The Friedkin and Necochea model involves regressing achievement on size, SES, and the product of SES and size (interaction term). If a significant interaction effect is found, effect sizes (ESs)at varying levels of SES can be calculated by taking the partial derivative of the regression equation. Standardizing the partial derivative and evaluating the resulting expression at chosen SES intervals gives the ES of size on achievement at those SES levels.

The partial derivative is a procedure in calculus and constitutes one of the original features of this method. Any use of calculus in educational studies is unusual, and hence merits careful explanation, which is provided in the following paragraphs.

In calculus, the derivative (often written as "dy/dx") gives the value of the change in a dependent variable, y, associated with change in a single independent variable, x. The derivative is a ratio, often construed as a generalized form of slope (familiar in algebra as the ratio of rise over run, or $[y_2 - y_1]/[x_2 - x_1]$). The regression coefficient, of course, provides an estimate of slope in regression analysis, with regression coefficients appearing as constants in regression equations (during the process of taking a derivative it is important to distinguish which values are constant and which vary).

Unlike the derivative, the partial derivative (like the partial regression coefficient) is particularly useful in working with equations with two or more independent variables (e.g., as in regression equations). The partial derivative merely gives the rate of change in the function (i.e., the value of the dependent variable) with respect to one independent variable as another is held constant. This resembles the way in which partial regression coefficients give the influence of one variable on another when the influence of a third variable is eliminated.

To calculate the partial derivative, one variable (either x or y) is held constant while differentiation proceeds with respect to the other; the variable "held constant" is treated during differentiation as if it were a constant. Afterwards, values of the variable held constant (socioeconomic status, in this case) can be substituted in the resulting equation to calculate actual values of the partial derivative function (i.e., to determine the influence of the variable not held constant on the dependent variable with respect to differing values of the variable that was held constant during partial differentiation). In this study the effects of size on achievement are hypothesized to vary by socioeconomic status, and the partial derivative hypothetically provides a mechanism to evaluate the differences.

For this study, the applicable partial derivative will give the effect of change in size (defined as cohort-level enrollment or total district enrollment as applicable) on achievement (test scores) as socioeconomic status (free-and-reduced-price-meal rates) is held constant. The general form of the mathematical model proposed is given by the following equation:

$$f(z) = ax + by + cxy \qquad \text{(equation 1)}$$

where

a, b, and c are the unstandardized regression coefficients (of size, socioeconomic status, and the interaction term, respectively);

z represents values of achievement (the dependent variable);

x represents values of size (one independent variable); and

y represents the values of the socioeconomic status variable (the second independent variable).

Holding y constant, and differentiating z with respect to x, the relevant partial derivative is given by the equation:

$$f_x(z) = a + cy \qquad \text{(equation 2)}$$

This equation can be used to calculate the effect on the dependent variable (z, achievement) for differing values of the variable held constant during partial differentiation (y, socioeconomic status).

Standardizing the partial derivative renders it as an "effect size," which is more easily interpretable than the unstandardized form[33].

---

[33]The derivation of effect size is elementary algebra and it proceeds as follows:

* Recall that a + cy = change in dependent variable (achievement) per change in size and, thus,
* a + cy represents a rate, call it dz/dx (i.e., change in achievement per change in size);
* to standardize, assume that the ES = some k, such that
* $(dz/dx) = k\ (\sigma_z / \sigma_x)$
  [that is, some constant times the ratio of the standard deviation for achievement and the standard deviation for size will equal the rate of change in achievement per change in size, i.e., the partial derivative], and therefore:
* $(dz/dx)(\sigma_x/\sigma_z) = k$
* and since (a +cy) =dz/dx, the untransformed rate,
* $k = (a + cy)(\sigma_x/\sigma_z)$, as given in the following discussion.

The total, standardized effect of school size on achievement (in standard deviation units) is given by the following formula:

$$\text{effect size} = (a + cy)(\sigma_x/\sigma_z) \qquad \text{(equation 3)}$$

This is the final form of the regression equations, and it represents the change in achievement (in standard deviation units) expected with change in size (also in standard deviation units) among cases with a particular SES.

APPENDIX B

Regressions with Class Size (Ohio "Classified Staff"/school Enrollment) as Control Variable

Grade 4 (regular pass rate)

Coefficients

	Unstandardized Coefficients		Standardized Coefficients	t	Sig.
	B	Std. Error	Beta		
(Constant)	69.475	1.217		57.100	.000
CLAS_SIZ	.364	.091	.069	3.978	.000
centered ln_size	-2.478	.555	-.078	-4.469	.000
centered ln of adc	-9.808	.271	-.721	-36.135	.000
INT_ADC	-2.388	.433	-.110	-5.520	.000

a Dependent Variable: read,math,writ,citi,sci average (4th)

Grade 6 (regular pass rate)

Coefficients

	Unstandardized Coefficients		Standardized Coefficients	t	Sig.
	B	Std. Error	Beta		
(Constant)	51.669	1.400		36.905	.000
CLAS_SIZ	.351	.111	.065	3.168	.002
centered ln_size	-.943	.513	-.037	-1.838	.066
centered ln of adc	-10.426	.313	-.685	-33.308	.000
INT_ADC	-2.777	.418	-.135	-6.640	.000

a Dependent Variable: math,read,writ,citi,sci average (6th)

Grade 9 (regular pass rate)

Coefficients

	Unstandardized Coefficients		Standardized Coefficients	t	Sig.
	B	Std. Error	Beta		
(Constant)	78.568	1.296		60.647	.000
CLAS_SIZ	.146	.096	.041	1.521	.129
centered ln_size	-3.956	.616	-.179	-6.427	.000
centered ln of adc	-6.248	.424	-.491	-14.746	.000
INT_ADC	-2.741	.482	-.188	-5.686	.000

a Dependent Variable: math,read,writ,citi average (9th)

Grade 12 (regular pass rate)

Coefficients

	Unstandardized Coefficients		Standardized Coefficients	t	Sig.
	B	Std. Error	Beta		
(Constant)	64.424	1.219		52.851	.000
CLAS_SIZ	-.170	.089	-.060	-1.919	.055
centered ln_size	1.951	.616	.107	3.167	.002
centered ln of adc	-6.269	.411	-.579	-15.242	.000
INT_ADC	-.849	.482	-.068	-1.760	.079

a Dependent Variable: math,read,writ,citi,sci average (12th)

Grade 4 (advanced pass rate)

Coefficients

	Unstandardized Coefficients		Standardized Coefficients	t	Sig.
	B	Std. Error	Beta		
(Constant)	2.533	.103		24.673	.000
CLAS_SIZ	1.687E-02	.008	.038	2.188	.029
centered ln_size	-4.177E-02	.047	-.016	-.891	.373
centered ln of adc	-.802	.023	-.707	-35.029	.000
INT_ADC	-.167	.037	-.093	-4.586	.000

a Dependent Variable: SQRT4AD

Grade 6 (advanced pass rate)

Coefficients

	Unstandardized Coefficients		Standardized Coefficients	t	Sig.
	B	Std. Error	Beta		
(Constant)	2.310	.100		23.141	.000
CLAS_SIZ	1.030E-02	.008	.028	1.304	.192
centered ln_size	.138	.037	.079	3.745	.000
centered ln of adc	-.664	.022	-.642	-29.618	.000
INT_ADC	-.155	.030	-.110	-5.143	.000

a Dependent Variable: SQRT6AD

Grade 12 (advanced pass rate)

Coefficients

	Unstandardized Coefficients		Standardized Coefficients	t	Sig.
	B	Std. Error	Beta		
(Constant)	3.294	.094		34.986	.000
CLAS_SIZ	-4.976E-03	.007	-.021	-.726	.468
centered ln_size	.219	.048	.145	4.613	.000
centered ln of adc	-.523	.032	-.582	-16.476	.000
INT_ADC	-.159	.037	-.154	-4.272	.000

a Dependent Variable: SQRT12AD

The Matthew Project

The Matthew Project, with funding from the Rural Challenge Policy Program (now known as the Rural School and Community Trust Policy Program), investigated the possible academic excellence and equity effects of school and district size in Georgia, Montana, Ohio, and Texas. The project title refers to a parable about stewardship in the gospel according to Matthew (13:12): "For whosoever hath, to him shall be given, and he shall have more abundance: but whosoever hath not, from him shall be taken away even that he hath." Building on previous research efforts in Alaska, California, and West Virginia, the Matthew Project was particularly concerned to investigate the possible contributions of smaller school size to academic success in impoverished communities.

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