# Is Large More Effective than Small is Beautiful?
## Size and Performance of Primary Schools in Poland[1]

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**Abstract**

We investigate the size-related features of the production function of Polish primary schools. The interplay of small schools ineffectiveness and of organizational and social difficulties appearing in large schools implies that the relationship between school size and student achievement is non-linear, with the optimal size crucially dependent on the social characteristics of the served population (such as average income per capita). Busing is found to have negative effect on performance, related to average distance of student transportation. The findings present several challenges to consolidation policies on quality ground, quite independent of the more common cost considerations.

**Keywords**:

school production function, educational achievement, school size, class size, school consolidation

**Introduction**

The massive demographic changes put a serious adaptation stress on the school systems throughout the Central and Eastern Europe. As student numbers decline, the school and class sizes also decline, decreasing the efficiency (through higher unit costs) of provision of

education, and hindering the efforts to improve quality. This adaptation stress is particularly painful in Poland, with its huge rural population living in relatively underdeveloped and poor areas. The dilemmas facing the local governments, the owners of Polish primary and secondary schools since 1996 and 1998 respectively, may be summarized crudely as either maintaining small, inefficient rural schools, often considered to be academically rather poor, or consolidating them into larger schools, and encountering stiff opposition from parents and teachers alike, as well as significant student transportation problems (interestingly, school consolidation is usually referred to in Poland as *network rationalization*, a term which tries to hide the stark reality of school closures).

In this context the research into the quality of education becomes particularly relevant. The local governments in Poland, although largely motivated by the financial constraints under which they operate, are very sensitive to the issues of education quality, in part because the school budgets form a very substantive part of local budgets, and in part because of the political pressure coming from the parents as voters. It was nevertheless very difficult for them to take education quality into account, because the available measures of school quality were very indirect. The situation changed after the introduction in 2002 of first independent national test of students' skills, administered and assessed across Poland by the National Examination Commission. In the first reaction, many mayors felt the temptation to "punish" and "reward" school principals based on the outcomes of the students' tests, in near total oblivion to the fact that the test results, according to numerous and well established research, depend crucially on the parental characteristics (primarily, the social and economic status SES), and also on peer effects (poor students put into a strong performing peer group improve their results considerably). It is therefore clear that better understanding of factors influencing the school outcomes, with special emphasis on factors under the influence of local governments, such as the use of different school resources, may have significant and positive impact on local education policies.

The economic interest in organizational factors influencing the education quality, with parental characteristics controlled, is due to the debate over the education production function. While there is no doubts that the per student costs incurred in larger, consolidated schools are lower, the real question is whether those resources (inputs) are necessarily used in a more efficient manner when judged from the quality (output) point of view. There are grounds to believe that in larger schools, due to their lower per student expenditures, funds freed through

higher student teacher ratio can be used more effectively to improve school equipment and teaching condition, and also perhaps to employ better teachers. On the other hand, it is also often asserted that smaller schools, with their more immediate contact between the students and teachers, and safer teaching ambience (including reduced risks of drugs and other social problems), promote better learning. The factors shaping the efficiency of use of education resources are affected by legal and organizational constraints under which the schools operate in each country, as well as by historical differences and by mentality of all employed in the sector. In other words, education production function necessarily has national characteristics, and the present study aims to capture those characteristics for Poland.

In this respect Poland is fortunate because the data coming from the universal tests (three consecutive years already) allows for the first time to analyze empirically the impact of school organization and management on the educational outcomes of pupils. The researchers can also include in the analysis the controversial issue of school consolidation. After reviewing the methodological approaches in analyzing the effects of different patterns of resource use on the quality of education, we focus on the test results of primary school graduates in Mazowsze, a major, centrally located region of Poland.

Basing on the international literature review, and preliminary observations on the determinants of school achievement in Poland (Herczynski, Herbst 2002, Herbst 2004), in the present study we will seek the answers to the following questions:

- What is the school-size effect on average students performance? Is it linear? Is it different in impoverished and affluent communities?
- Does the number of classes in a single grade influence educational outcomes?
- Does class size matter for the achievements?
- What is the effect of rural busing (and in general traveling to distant school) on school performance?

**Literature review**

School consolidation has two effects on the schools which remain in operation:
- Increased average school size, class size and the number of classes per grade,
- Diversified social and economic status (SES) of the students' parents.

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The impact of those changes on student achievement received very little research attention in Poland until now. However, it has been addressed in numerous studies in the US, in Western Europe and in other regions. Those studies did not result in some general consensus and even on the basic empirical level the disagreements between researchers remain significant. We review the research on the impact of school size, of class size and of composition of student population.

**School size effects**

Not surprisingly, the estimated effect of size depends on how school performance is measured. Howley, Strange and Bickel (2000) point out that American studies based on outcomes (school achievements, completion rates, attendance) recommend smaller size than those based on inputs (teacher quality, instructional materials, specialized staffing). In turn, studies based on the value of community (social behavior and activity, interactions with peers and teachers) recommend sizes smaller than those based on outcome.

If student test achievements are used as the main indicator of school performance, the rule becomes simple. Andrews, Duncombe and Yinger (2002) reviewed the American literature since 1980's till the present and concluded that, almost universally, the research reveals negative influence of school size on student performance. Larger schools are associated with lower achievements, with school and non-school inputs are held constant. They note, however, that although most studies assume a linear relationship between size and performance, it is very likely that in reality decreasing returns to size arise only for large schools. The review suggests that elementary school size begins to negatively affect the test results for enrollment above 600. The optimal size of high schools seems to be between 600 and 900[3]. Other literature reviews, such as Imsher (1997) and Raywid (1999), also conclude that US evidence shows that the educational quality deteriorates as school size increases above some threshold. Raywid estimates the reasonable enrollment to be around 350 for the elementary schools and 900 for high schools.

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[3] In Poland such school size is considered quite large. In 2001/2002, the average enrollment in primary school have not exceeded 200.

Some studies reveal that school size has different effect on performance depending on the social status (SES) of students. A short review of this more nuanced research is offered by Howley, Strange and Bickel (2000). For instance, Howley (1994) demonstrates that smaller school size improves the achievements in schools serving impoverished communities. Friedkin and Necochea (1988), working with California school data at fourth grade level, also concluded that smaller school size benefited school performance in impoverished communities, but larger schools were more efficient in relatively wealthy areas. Due to the nature of school work, namely to the cooperative process of learning, it is not surprising that social characteristics of student population influence the productivity function. For students coming from impoverished and educationally disadvantaged communities, with often lower motivation and lower interest in academic subjects, smaller schools become more efficient despite higher per student costs.

Finally, a number of studies indicate that small and large schools differ substantially in equity effect. Lee and Smith (1996) found that although, at student level, poverty exerts a strong negative effect on high school performance, this effect is sharply reduced in schools with enrollment below 300. The difference in equity effects was also found within the so called Matthew Project – a large scale research conducted in four US states (Howley and Bickel 1999). In all the states the relationship between SES and student performance in small schools was substantially weaker (between 20% and 70%) than in large schools. In other words, smaller schools seem to be a stronger instrument of equalization of students' chances.

It must be said, however, that it is not clear to what extent the observed difference in equity effect is directly related to school size. Student communities in rural or underdeveloped areas (where average school size is relatively small) are frequently characterized by low variation in SES. The weak relationship between SES and achievements may be reflection of this fact, and not the equalizing power of small school.

### Class size effects

In theory, small classes should favor high achievements, other inputs controlled. In a small class student have better access to the teacher and increased use of school equipment. The teachers can, in turn, spend more time working with individual students and better adjust the curriculum and textbook material to match specific needs of every student group.

Surprisingly, the empirical evidence for the impact of class size on educational achievements is less than conclusive. Hanushek (1996) shows that of the 277 empirical studies published between 1966 and 1995, less than 5% found a negative and statistically significant relationship between class size (or student-teacher ratio) and performance, while almost the same number displayed positive and significant relationship.

Akerhielm (1995) names two main reasons why past research has revealed such inconsistent result. First, due to missing data on actual class size, the student-teacher ratio for the entire school was frequently used. This led to measurement errors not only because the aggregate ratio was different than class level one, but also because different grades and individual classes may receive different didactic input. Moreover, missing teacher data led researchers to use student-employee ration in place of student-teacher ratio (including administration and support didactic staff such as counselors), further depressing the accuracy of indicators used.

The second reason is that allocation of students to individual classes, including to classes of different size, is rarely a random process. For example, if a school decides to assign poorly skilled pupils to smaller classes in order to provide them easier access to teachers and school equipment, we may expect the estimated effect of class size on performance to be upward biased. More ambitious students may also want to migrate to "better" classes, pushing up their size. Using actual class size data from US National Education Longitudinal Study (NELS) of 1988, and applying instrumental variables technique (2SLS) to correct for non-random distribution of pupils among classes, Akerhielm demonstrated that the effect of increasing class size is negative and significant for science and history achievement, and negative but insignificant for mathematics and English achievement of 8th graders. Interestingly, if OLS estimation was applied directly instead of 2SLS, the effect of class size turned out to be positive for the achievements in all investigated subjects. This observation, concludes Akerhielm, explains the unclear evidence from the past.

In turn, Wößmann and West (2002), have applied a method combining school fixed effects and instrumental variables to estimate the effect of class size on student performance within TIMSS (Third International Mathematics and Science Study) in 18 countries. They found considerable beneficial effects of smaller classes only in two countries (Greece and Iceland) and no class-size effect in other two (Japan and Singapore). In eleven countries the impact of

class size on school achievements was negligible. Similarly, Hoxby (2000) used 2SLS techniques to separate the variation of class size due to small variation in size of student populations, and concluded that there is no impact of class size on student achievement.

It is also worth noting that in some transition economies under financial distress, schools try to compensate for the very high per student costs by reducing the per class costs (see Herczyński 2003). This means that in some circumstances smaller classes, especially in rural areas, may be associated with actually reduced student access to various school resources, including qualified teachers and school equipment.

### **Busing and school composition**

Consolidation of schools involves busing pupils to distant facilities. It is frequently argued that besides reducing per student expenditures, busing improves the educational opportunities for rural pupils. Unable to hire good teachers for a large number of small schools, and to equip them all equally well, local governments may use consolidation to improve the access of wider groups of children to significantly better educational services. On the other hand, busing may introduce additional stress of its own on the students, and reduce parental cooperation and involvement in the school, especially for weaker students. The impact of school consolidation on student achievement is therefore a complex issue.

Indeed, there exists evidence proving that busing exerts direct adverse influence on students. Howley and Howley (2001) cites the study of Lu and Tweeten (1973) who confirmed a negative impact of duration of bus ride in Oklahoma on students achievements. Fox (1996) found that long bus rides reduce the number of household activities, limit recreational and sleep time, depress academic attentiveness and extracurricular participation.

There are also indirect effects of busing, namely changes in social composition of the schools. Restructuring of schools as a result of the consolidation process affects the learning conditions of both 'indigenous' and 'newcomer' students, that is of those who do and who do not change the school. Typically, SES of pupils bused to the school from distant localities is, on average, lower than SES of indigenous students. Indeed, it is a basic belief standing behind the idea of school consolidation (besides, naturally, cost reduction), that children from educationally

disadvantaged environment would benefit in their learning and in educational achievements, if they are mixed with those coming from better educated families.

Compositional effects are commonly recognized as a crucial determinant of educational achievement since the publication of Coleman Report (1966). Although Coleman et al. focused mainly on interactions between pupils, later research revealed that school composition affects also teachers and school management. A recent review of the existing studies led Thrupp, Lauder and Robinson (2002) to conclude that there exist three principal types of compositional effects. First, classmates learn from one another directly, acting as mutual learning resources, for example when the vocabulary of a student increases through interaction with other children, whose vocabulary is larger than his own. Peer effects may also arise because of shared aspirations and beliefs, through classroom disruption or learning atmosphere (peer pressure). Second, teachers may change the teaching methods in response to changes in class composition, for instance by adapting to weaker students (instruction effects). Finally, school composition do have impact on school curriculum, that has to be adjusted to the capacities of the pupils (managerial effects). Thus, the actual curriculum followed in the school is clearly dependent an the average ability of the schoolmates, and not only on one's own performance.

Inspired by Coleman, many researchers conducted empirical research on the compositional effects in schools. The analysis of peer effects is rather difficult because the those effects (like a class performing significantly better than other classes) are often due to selection (see Hoxby 2000a). Thus it is not surprising that the results are mixed. Strand (1998) finds no evidence for the compositional effects examining data on about 1700 students in 57 elementary schools in UK. In turn, Driessen (2002), applying multilevel analysis to Dutch primary schools, finds strong impact of school composition on the language performance of grade four pupils, weak effect on the math performance on the same grade and language performance on eighth grade, and finally, no effect on math performance on eighth grade.

In US, Hanushek, Kain, Markman and Rivkin (2001) have examined data on about 600,000 students (three age cohorts) from over 3000 public elementary schools in Texas. Removing school and grade fixed effects in addition to observable family and school characteristics, they found peer achievements to have positive effect on student achievement growth. Similar results were obtained by Vidgor and Nechyba (2004), who used data on all primary schools in

North Carolina. Controlling for family education, school resources and introducing school fixed effects, they found a significant, positive relationship between peer ability on third grade and achievements on fifth grade. Similarly, Hoxby (2000a) controlling for selection (either of the school or of the class, either by the parents or by the school system) finds significant impact of peers. Hoxby also finds that not all peer effects are due to the mean achievements of other students in the class. For instance, peer effects are stronger within race groups than across them. Moreover, in more female classes all students do better in math, even though average math results of male and female students are similar. This may point to instructional effects rather than peer pressure or learning from peers.

In general one has to agree with Thrupp, Lauder and Robinson claim (2002) that the balance of American and European evidence reaffirms the conclusions of Coleman report, that school composition exerts strong influence on student performance.

Leaving aside possible direct adverse impact of busing on student performance and focusing on school compositional effects, the findings of Coleman and his successors suggest that school consolidation and busing of pupils may be beneficent for the children from poor and uneducated environment. What about students from well situated/middle class families? Are they harmed by the changing social composition of their school (association with low SES children) in result of consolidation process? According to Coleman et. al (1966), not necessarily. Integration is asymmetric in effects, they claim, and has its greatest effect on those from educationally deficient backgrounds. Middle class children learn a lot at home, and family education makes them 'resistant' to the possible adverse influence of peers.

The asymmetry of compositional effects was confirmed in numerous studies, not only related to schooling. One of the most interesting was the experimental research by Falk and Ichino (2003), who found that productivity at office work depends on peer performance and this relationship is much stronger for low-productive workers than for highly productive ones.

According to a large part of available studies, the policy of mixing social classes in schools is promising and should help improve the average outcomes and reduce the gap in achievements between the children from middle class and poor, uneducated families. There are however reasons to believe that influence of poorly endowed peers on the well situated ones is not linear. As stated in Coleman Report, there is a threshold point, at which the negative effects of

peer poverty become much greater. It is because the numerical majority in a school sets the tone. The authors estimate that the threshold is around 60% of middle-class. Below this number, the impact of peers with low SES on the achievements of other students becomes significant. Similarly, the study of desegregated schools in Texas (Hanushek, Kain, Rivkin 2002) shows that if the number of black students in the school is large, the positive impact of desegregation decreases, especially for gifted students.

**Conceptual framework and data**

According to Lee and Barro (1997) the general form of educational quality determination function is:

$$(1) \quad Q_i = Q_1(f_i, s_i)$$

where *f* and *r* refer to family factors and to school resources respectively, and *Q* is measured by average test score. In this simple framework *f* is supposed to capture the effect of social environment on the educational outcome of an individual, while *r* refers to educational processes taking place within the school. Thus human capital and recurrent income (and other home resources important for education, such as family library and internet access at home) are included in *f*, while student teacher ratio and teacher qualifications (and other relevant school resources, like school equipment) is expressed by *s*.

For the purpose of our research, we consider separately a category of school characteristics related to scale of operation. We assume that *r* in equation (2) accounts only for those school resources that are not directly linked to size, such as per student expenditures, teacher qualifications and experience. The factor *n* will cover the size–related features of school, including school and grade enrollment, class size, and the number of classes per grade.

$$(2) \quad Q_i = Q_2(f_i, r_i, n_i)$$

The main goal of this paper is to verify the impact of *n* on average educational outcome Q of schools as both *f* and *r* are controlled. We also want to investigate the importance of changes in school mix, inevitably accompanying the increase of average school size in the districts undergoing consolidation process. As noted in the introduction, consolidation has both direct

and indirect impact on the achievements of students, including those who remain in their old school as local school networks is changed.

We conduct our analysis at the school level, with no data on individual students, so we cannot investigate the nature of school compositional effects for different groups of students involved in the process of consolidation. We can however verify the net effect of diversity resulting from school consolidation and from busing on the average educational achievement of school community. After including compositional effect $d$ related to the shift in school size, the general form of educational quality function will look as in equation 3:

$$(3) \quad Q_i = Q_3(f_i, r_i, n_i, d_i)$$

For the purpose of empirical tests, most of the relationships between the endogenous variable and the regressors are assumed linear. For the impact of school and grade enrollment on student performance both linear and quadratic specification have been tested, because of expected decreasing returns to size, as discussed in the literature on the subject. Additionally, in one of the equations grade size is expressed by the number of classes instead of enrollment. This takes into account the influence the number of classes on the functioning of the school and thus, possibly, on its performance. In order to avoid assumptions on the functional form of the relationship, instead of using one variable, the number of classes was introduced to the specification as the set of $k$ dummy variables for schools having 1 to $k$ classes at $6^{th}$ grade.

The dependent variable used in all specifications is the average test score (measured at school level) of students of the final, $6^{th}$ grade in the universal tests administered by Centralna Komisja Egzaminacyjna (CKE, Central Examination Commission) in 2002. Our source of data is regional branch of CKE, whose jurisdiction includes the capital city of Warsaw and the surrounding Mazowsze Region, and covers about 1,700 primary schools.

The students solve test problems in 5 different areas, with the maximal number of points to be obtained equal 50. We do not analyze separate skill areas and use only the total student scores. The average score in the region is 30,43.

Data on school enrollment, grade enrollment, and number of classes per grade come from annual statistical report S-02 submitted by schools to Central Statistical Office. We use the data from academic year 2001/2002.

Family resources are approximated by two school level variables: per pupil parental contribution to school budget in the scholar year 2000/2001 (the latest available) and share of pupils receiving social benefits in school community in 2001/2002. The source of the former variable is statistical report S-02, the latter comes from another schools report, namely S-09. We do not use other variables, such as education level of parents, if they are available only at the level of local governments.

The variables expressing the level of school resources (other than those related to size) used in our analysis are: teachers and administration salaries per student (calculated per student), headmaster's years of experience and headmaster's education (dummy indicating MA level or above). First of those was taken from 2001 obligatory report EN-3, prepared by the schools. The other variables come from the EWIKAN database on teachers, maintained by thee Ministry of Education and Sports.

Finally, data on busing and share of students living more than 3 km, more than 5 km and more than 10 km from school is taken again from S-02.

The descriptive statistics for the variables used in the analysis (excluding dummy variables) are presented in Table 1.

Table 1. Descriptive statistics for the variables used in the analysis

| Variable | Sample mean | Standard deviation |
|---|---|---|
| Log average test score | 3,41 | 0,09 |
| School enrollment | 191,08 | 190,53 |
| 6th grade enrollement | 33,70 | 33,30 |
| Average class size at 6th grade | 17,45 | 7,81 |
| Parental contribution per pupil | 26,90 | 21,03 |
| Share of students receiving social benefits | 0,01 | 0,04 |
| Log per student expenditures on salaries | 7,76 | 0,54 |
| Average distance to school | 1,717 | 1,79 |

| | | |
|---|---|---|
| Share of bused students | 0,129 | 0,21 |
| Share of students living more than 3km from school | 0,15 | 0,23 |
| Headmaster's experience (yrs) | 9,25 | 6,59 |

## Results

The preliminary OLS regressions on the sample of primary schools in the Polish region of Mazowsze (see previous section for details) reveals positive, although very weak returns to increasing school size, measured as the logarithm of school enrollment[4]. As the enrolment rises by 10%, an improvement of 0,08% in the test score is expected. This result is significant at 0,08 level. The effect is stronger if we restrict attention to the size of final (6th) grade cohort, that is to the students whose achievements are verified by the cognitive test. Here we can expect a shift of 0,13% in response to increasing the number of 6th grade students by 10% (significant at 0,05 level). A positive return to increasing school size is inconsistent with the evidence from other countries (in particular from the U.S), where large school size is proved to exert a negative influence of student achievements. To investigate this problem more carefully we check for non-linearity of size-performance relationship by introducing quadratic specifications of school size (specification 1 in Table 2 below) and of the size of the 6th grade (specification 2), and alternatively, measuring size by the number of classes (instead of pupils) at 6th grade (specification 3).

Table 2. Estimations of size-performance relationship in primary schools

| Variable        Equation | 1 | | 2 | | 3 | |
|---|---|---|---|---|---|---|
| Constant | 3,3206 | (46,3) | 3,3139 | (43,6) | 3,3088 | (43,5) |
| Warsaw | 0,0309 | (4,22) | 0,0306 | (4,18) | 0,0295 | (3,89) |
| Rural | -0,0293 | (-3,31) | -0,0234 | (-2,37) | -0,0281 | (-2,79) |
| Nonpublic | 0,1214 | (8,61) | 0,1202 | (8,54) | 0,1111 | (7,56) |
| Parental contribution('00) | 0,0264 | (2,43) | 0,0292 | (2,66) | 0,0296 | (2,68) |
| Social benefit | 0,0689 | (1,31) | 0,0760 | (1,44) | 0,0808 | (1,50) |
| Log per student expend. | 0,0139 | (1,79) | 0,0131 | (1,51) | 0,0143 | (1,63) |
| Headmaster experience | -0,0001 | (-0,32) | -0,0000 | (-0,07) | -0,0000 | (-0,08) |

[4] These estimations are not presented in the tables. In order to keep the article short the article we briefly discuss their results in the text without reporting all estimators and statistics.

| | | | | | |
|---|---|---|---|---|---|
| Headmaster MA, PhD | -0,0153 | (-2,26) | -0,0142 | (-2,05) | -0,0143 | (-2,06) |
| Avg class size | -0,0006 | (-0,09) | | | |
| Avg class size 6th grade | | | -0,0005 | (-0,08) | |
| Enrollment | 0,0001 | (2,34) | | | |
| Enrollment sq | -7,6e-8 | (-1,81) | | | |
| enrollment at 6th grade | | | 0,0007 | (2,45) | |
| enrollment at 6th grade sq | | | -3,07e-6 | (-2,29) | |
| Avg class size grade 6 (1) | | | | | 0,0004 | (0,64) |
| Avg class size grade 6 (2) | | | | | -0.0007 | (-2,38) |
| Avg class size grade 6 (3) | | | | | -0.0005 | (-1,42) |
| Avg class size grade 6 (4) | | | | | -0.0006 | (-1,70) |
| Avg class size grade 6 (5) | | | | | -0.0009 | (-1,37) |
| Avg class size grade 6 (6) | | | | | -0,0010 | (-1,78) |
| Avg class size grade 6 (>6) | | | | | 0,0212 | (3,15) |
| 2 classes at 6th grade | | | | | 0.0281 | (1,98) |
| 3 classes at 6th grade | | | | | 0,0325 | (2,02) |
| 4 classes at 6th grade | | | | | 0,0313 | (1,72) |
| 5 classes at 6th grade | | | | | 0,0614 | (3,20) |
| 6 classes at 6th grade | | | | | 0,0330 | (1,32) |
| >6 classes at 6th grade | | | | | -0,5154 | (-3,19) |
| | | | | | |
| F (r,df) | 17,95 | (11,1164) | 17,44 | (11,1140) | 9,65 | (21,1130) |
| Adjusted R2 | 0,15 | | 0,14 | | 0,15 | |
| N | 1176 | | 1152 | | 1152 | |

Heteroscedasticity adjusted t-statistics are reported in parentheses

In equations 1 and 2 the assumed functional form of size-performance relationship is the following:

$$p = \alpha + \beta n_i + \gamma n_i^2$$

The estimated coefficients (positive $\beta$ and negative $\gamma$) suggest that as enrollment increases, the student performance increases at first and eventually begins to deteriorate due to large school effects. Similarly as in log-linear specifications, the relationship is less noisy (stronger in terms of statistical significance) when measured directly at 6th grade level. Nevertheless, even when total school enrollment is used, the model fits the data better than linear approximation.

Figure 1. Size-performance relationship at school and grade level
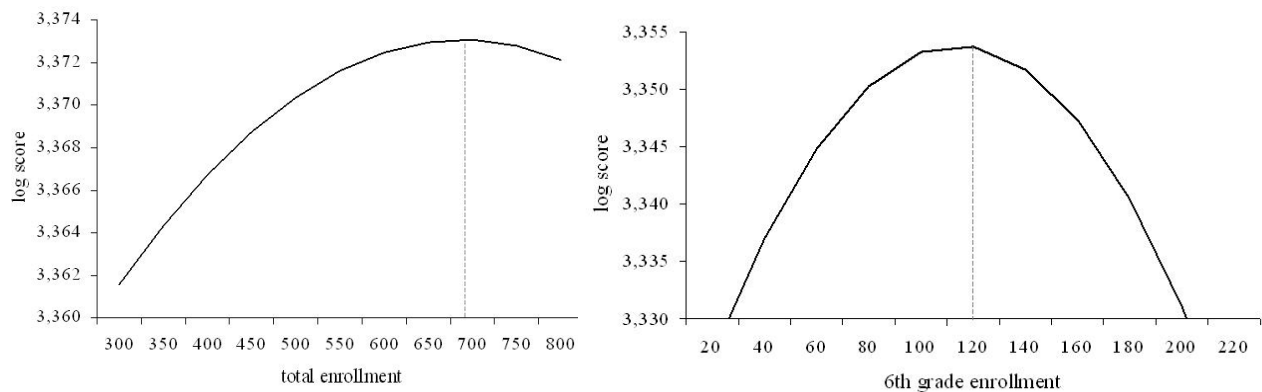


As shown in Figure 1, the estimations indicate that, with other factors controlled, the impact of size on average achievement becomes negative for school enrollment above 690 and for 6th grade enrollment exceeding 120. Those numbers indicate the 'optimal' school and grade size, independent of the variation in other school and family resources influencing educational outcomes.

If the enrollment at each grade is assumed equal, 120 students at 6th grade means 720 in total in an 'optimal sized' school. This is slightly more than 690 estimated using total enrollment as a direct measure. The difference is probably due to the demographic trends in Poland, with decreasing number of students attending schools every year. If the optimal 6th grade size is used, and lower grades sizes are adjusted for the demographic factor, we obtain the optimal school size of 660, which is about 5% lower than the direct estimates.

Although the performance-maximizing school size seems to be similar regardless if it is estimated using school or grade level variables, the elasticity of student performance to grade size is slightly higher than to overall school enrollment. Figure 1 shows that, as the size of 6th grade moves from regional average (32) to 'optimal' enrollment (120), the expected outcome rises by 2%. The analogous change in total enrollment (from 190 to 690) would be associated with only 1,6% gain in average test score. This asymmetry points most probably to the

difference in the teaching process between early grades (grades 1 through 3 are referred to as 'initial teaching', with one teacher per class) and later grades (subject teaching with multiple teachers). The size effects are stronger for later grades, because the effective use of school resources is more difficult at this stage of instructional process.

While enrollment is the most common measure of school or grade size, it may not be fully adequate for the managerial and instructional processes taking place in schools. It might be the case that the relationship between size and performance is related more to the number of classes, than pupils. Creating new class is a 'milestone' in the process of increasing school size. It affects school functioning in more ways than just enrolling additional students. In particular, it requires employment of more teachers and it intensifies the use of school resources such as space and laboratories. It also make the school structure more complicated and imposes greater requirements on school administration. Moreover, if the effect of creating each additional class at given grade is investigated separately (as it is in equation 3, see below), we are able to obtain the approximation of the shape of size-performance relationship without assuming a priori any functional form (linear, log-linear, quadratic, etc.).

Equation 3 includes dummies for schools having from 2 to 6 classes at final grade. Schools with only one class are used as a reference category. Equation 3 also includes the variables for the average size of sixth grade class when there are two, three etc. classes at grade $6^{th}$ (those variables are zero for schools with a different number of $6^{th}$ grade classes).

The results of the estimation show (although not all the class variables are statistically significant) that the average test score increases till the number of classes reaches five, and then starts falling. Unfortunately, there are very few schools with more than 6 classes at $6^{th}$ grade in the sample (they were given a common dummy variable) so the coefficient for 'above six' variable is not credible.

An interesting observation can be made about class-size variable, that is calculated separately for each group of schools according to the number of classes at final grade. Generally, the impact of class-size on educational outcome is negative, independently on the size of school. The only exceptions are observed in schools with one class at $6^{th}$ grade (in those schools class size is simply grade size), where the class-size variable is statistically insignificant even at

α=0,5 and in very large facilities having over 6 classes per grade, being too few to produce any credible result.

However, although class-size impacts performance negatively for almost all school sizes, the strength of this effect depends on school size. Generally, as the number of classes at grade 6 (and thus enrollment at grade 6) increases, so does the magnitude of the impact of class-size on average achievement. For example, if we take schools with three classes in the final grade, an increase in average class size by 10 students would be associated, ceteris paribus, with a drop in average test score by 0,5%. In turn, similar change in school with six classes at final grade would have effect twice as strong.

As the regression coefficients discussed here are not significant, further research is needed to understand their behavior. We can put forward a hypothesis, however, that for larger schools the importance of smaller classes increases. In other words, while very large schools, through difficulties of management and of creating an atmosphere suitable for learning, have negative impact on student achievement, there is some compensation which can be derived from using smaller classes.

Interestingly, the obtained optimal school size is very close to that stated by Andrews, Duncombe and Yinger (2002) on the basis on the review of American literature, namely 600 students for an elementary school. At the same time, Andrews et al. report that most of the existing research that test only for linear relationship between school size and performance, prove this relationship to be negative. The conclusion must be drawn that, if we consider the influence of size on school outcome to be nonlinear as in (a), large part of American schools is probably located at the downward section of the curve. The average size of Polish elementary school is much smaller (below 200). Only about 3% of schools in Warsaw region enroll more than 690 pupils, and 4% enroll more than 120 pupils at 6th grade. Therefore, vast majority of them place themselves on the upward section of the curve presented on Figure 1. This would explain why linear or log-linear specifications return positive relationship between size and performance, as opposed to most of US research.

As discussed in previous section, some research showed that large school size has stronger negative effect on student performance in communities characterized by low SES. The argument is that middle class children obtain much of their education at home and their

educational outcomes rely less on school quality and resources. In turn, the achievements of students from low educated and poor environment depend heavily on school performance, since school has to compensate them for the education they do not receive at home. Smaller schools allow better communication between students and teachers, ease the adjustment of curriculum to the capabilities of the children, and are in general exhibit more 'individual' approach to the pupil. One may say that if school has to fulfill some functions of the family, it should resemble the family itself. This reasoning explains the finding of US research that for poorer communities smaller schools are more efficient. We may now test this hypothesis in the Polish conditions.

Equation 4 in Table 3 is simply restatement of equation 1 from Table 2, estimated on pooled sample covering about 1200 primary schools in 320 local governments in Mazowsze region. Specifications 5 and 6 cover the local governments with per capita average personal income below and above the median value respectively.

Table 3. Estimations of size-performance relationship in poor and affluent communities

| Variable           Equation | 4 | | 5 | | 6 | |
|---|---|---|---|---|---|---|
| Constant | 3,3206 | (46,3) | 3,2831 | (34,9) | 3,3486 | (26,9) |
| Warsaw | 0,0309 | (4,22) | | | 0,0311 | (4,07) |
| Rural | -0,0293 | (-3,31) | -0,0175 | (-0,39) | -0,0348 | (-3,41) |
| Nonpublic | 0,1214 | (8,61) | | | 0,1229 | (8,37) |
| Parental contribution('00) | 0,0264 | (2,43) | 0,0141 | (0,52) | 0,0252 | (2,13) |
| Social benefit | 0,0689 | (1,31) | 0,0529 | (0,76) | 0,0750 | (1,04) |
| Log per student expend. | 0,0139 | (1,79) | 0,0189 | (2,08) | 0,0112 | (0,81) |
| Headmaster experience | -0,0001 | (-0,32) | -0,0013 | (-1,79) | 0,0005 | (1,45) |
| Headmaster MA, PhD | -0,0153 | (-2,26) | -0,0301 | (-2,69) | -0,0026 | (-0,33) |
| Avg class size | -0,0006 | (-0,09) | -0,0010 | (-0,75) | -0,0011 | (-1,18) |
| Enrollment | 0,0001 | (2,34) | 0,0003 | (2,21) | 4,35e-5 | (1,00) |
| Enrollment sq | -7,6e-8 | (-1,81) | -2,43e-7 | (-1,47) | -2,37e-8 | (-0,60) |
| | | | | | | |
| Select by average personal income in the municipality | All | | Below median | | Above median | |
| | | | | | | |
| F (r,df) | 17,95 | (11,1164) | 3,7 | (9,491) | 16,3 | (11,663) |
| | | | | | 2 | |
| Adjusted R2 | 0,15 | | 0,05 | | 0,21 | |
| N | 1176 | | 501 | | 675 | |

The results of the estimations confirm that in less developed areas (with lower average personal income), school outcome is much more sensitive to school size that in more affluent environment. In the municipalities with average income above median both variables related to school size (enrollment and square of enrollment) loose statistical significance. Moreover, the estimated optimal school size is different for the two samples. As shown in the Figure 2, the size-performance curve estimated in specification 5 (poorer communities) reaches its maximum for the enrollment of 590, all other factors controlled. In turn, for more affluent local governments, the optimal school size would be about 900, that is about 52% more.

Figure 2. Size-performance relationship in 'affluent' and 'impoverished' communities*
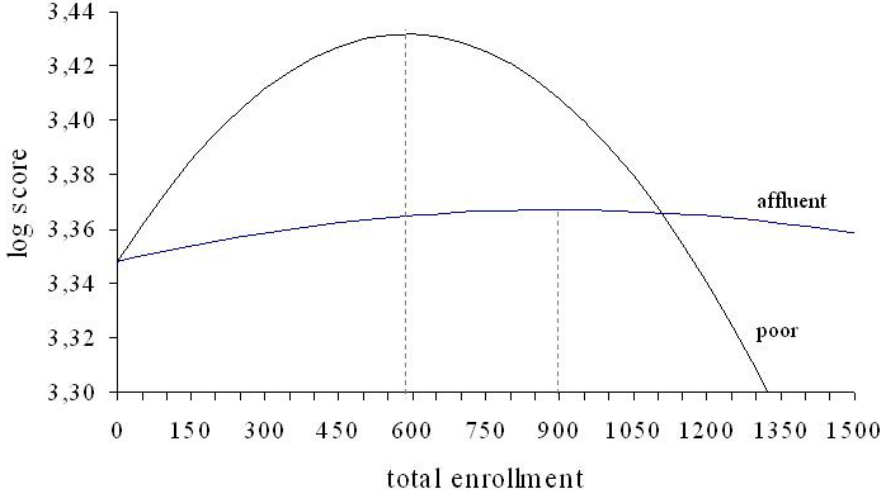


* For the clarity of the picture the size-performance relationships in poor and affluent communities were assigned the same intercept

Due to the insufficient sample size and specific features of rural areas of the region (in large part being residential suburbs of Warsaw), we could not effectively test for the impact of other environmental factors, such as local level of schooling of the adult population or level of urbanization, on the optimal school size. It seems however reasonable to assume that as better measures of SES are taken into account, the optimal size of the primary school will be even more varied. This finding has very important implications for consolidation policies. Indeed, it implies that there cannot be a uniform consolidation standard, and that there are important limits to consolidation arising purely from quality considerations. In rural and relatively poor and under-educated communities, the optimal school size is expected to be significantly lower

than in the more affluent cities. This may be in contrast to purely financial considerations, which will in general favor most consolidation moves.

School consolidation involve busing students from small localities to the facilities in distant towns. This may have both direct and indirect (through school compositional effects) impact on achievements, as described earlier in this text. Since we have no access to data on individual students in Polish schools, the importance of different effects related to busing cannot be addressed separately. What is however feasible, is to verify the net impact of busing on the performance of school to which pupils are bused.

In the following specifications busing to school is expressed by three different variables: share of bused students in school community, share of students living in distant localities, and thus allowed by the regulations to benefit from school transport and average distance from home town to school among students living more than 3 km away.

Table 4. Estimations of the impact of busing and average distance to school on school performance

| Variable          Equation | 7 | | 8 | | 9 | |
|---|---|---|---|---|---|---|
| Constant | 3,3599 | (75,4) | 3,3561 | (74,2) | 3,3704 | (37,8) |
| Warsaw | 0,0317 | (4,40) | 0,0311 | (4,31) | 0,0283 | (3,89) |
| Rural | -0,0374 | (-5,56) | -0,0386 | (-5,66) | -0,0386 | (-5,65) |
| Nonpublic | 0,1216 | (8,36) | 0,1213 | (8,34) | 0,1192 | (8,24) |
| Parental contribution('00) | 0,0250 | (2,28) | 0,0242 | (2,25) | 0,0239 | (2,21) |
| Social benefit | 0,0746 | (1,42) | 0,0719 | (1,36) | 0,0737 | (1,41) |
| Log per student expend. | 0,0101 | (1,75) | 0,0109 | (1,85) | 0,0096 | (1,63) |
| Headmaster experience | -0,0001 | (-0,28) | -0,0001 | (-0,21) | -0,0001 | (-0,17) |
| Headmaster MA, PhD | -0,0142 | (-2,11) | -0,0154 | (-2,25) | -0,0155 | (-2,29) |
| %busing | -0,0147 | (-1.19) | | | | |
| %travel from distant locality | | | -0,0125 | (-1,05) | 0,0083 | (0,53) |
| Average distance to school | | | | | -0,0041 | (2,07) |
| | | | | | | |
| F (r,df) | 21,39 | (9,1159) | 21,36 | (9,1149) | 19,73 | (11,1148) |
| Adjusted R2 | 0,14 | | 0,14 | | 0,15 | |
| N | 1169 | | 1159 | | 1159 | |

As can be seen from specifications 7 and 8, the presence of students coming from distant localities has negative effect on average school outcome (all students, not only the bussed

students), however both magnitude and statistical importance of this result is very low. An increase in the share of bused (or simply living in big distance from school) students by 10 percentage points would be associated, ceteris paribus, with a drop in average test score by 0,13% to 0,15%. What exerts stronger influence on school performance is the average distance challenged by the pupils living more than 3 km away from school. As it increases by 1 km, the expected drop in average test score is about 0,5%, with statistical significance confirmed at 5% level. This is a rather unexpected finding and it certainly needs more detailed analysis (preferably on a larger school sample and individual student data). Two possible ad-hoc explanations may be however formulated. First, it is possible that we observe mainly direct adverse effects of student transportation, restricted to 'traveling' students (average busing distance is related to the time spent by students on the bus). We may also suspect the magnitude of school compositional effects to depend on school catchment area. This may occur if students from remote, small villages come from less educated families and have much lower motivation to study that do the children bused from closer localities. However, it seems that the quality of education is largely uniform (and very low) among Polish rural areas, and thus the compositional effect mentioned above should be reflected also by the impact of the share of bused students in school community. Therefore, of the two immediate explanations of estimation results, direct adverse effects of busing seem to be more probable.

The conducted analysis reveals a very interesting quality trade-off which must be faced by any consolidation policy, and which is completely independent of any cost considerations. Indeed, given small size of most Polish primary schools, consolidation will increase the size of the remaining schools in the municipality and thus will contribute to better student outcomes. On the other hand, it will also increase the distances travelled and depress the test results. To see this trade-off more clearly, let us consider a simple example of a rural local government facing the decision to close a small school of 50 students and of moving them to a nearby larger school of 250 students. Keeping other factors constant, the size increase will benefit both 'indigenous' students (estimated increase of 0,8%) and 'new-coming' students (increase of 5,4%), thus the benefits for the 'new-comers' are, not surprisingly, much larger[5]. However, we need to take into account also the net effect of increased busing distance. The

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[5] The estimation are based on the coefficients from equation 5 in Table 3, thus we assume that the municipality considered in this example is rather poor (below median personal income).

estimated drop in average school performance due to 1 km increase in average distance to school among students living at least 3 km away is about 0,41%, ceteris paribus (see equation 9 in Table 4). Assuming for the moment that busing has symmetric influence on local students and newcomers (this assumption is not realistic, but unavoidable with the aggregated data we use), the benefits of consolidation for the 'indigenous' students are wiped out as the distance between schools exceeds 2 km. If the distance is larger than 13,5 km, also the benefits for 'new-comers' are overset by the negative influence of the busing.

Although such threshold distances based on estimated equations can be only treated as putative, they are helpful in understanding the nature of the trade-off between the rewards of more effective larger schools and quality losses due to longer distance busing.

Finally we pause to make a few remarks about the behavior of control variables used in Tables 2-4. The very significant positive impact of non-public schools is due to their selective intake, their graduates score on average 12% above other students. The use of dummy variables for Warsaw and for rural schools means that the reference are urban schools outside of Warsaw. Warsaw students outperform other urban students by 3%, and the rural schools students by 6%. This is not surprising, given that, living in a metropolis, children have access to educational resources unavailable elsewhere. The gap may also partially reflect the difference in quality of parents education, although parents' socioeconomic status is proxied by other variables in the specification. We note that 3% score difference amounts to one full point received in the test (see previous section) and is considered an important difference of test results.

In general, per student spending is not significant for students outcomes, in contrast to parents SES. This finding is in line with part of American literature (see Hanushek 1986, 1996), although the heated debate about the impact of financial resources on student outcomes continues. Interestingly, however, we note that an exception is specification 5, which is restricted to poorer communities. It seems that in poor environment, where as discussed above, school must take over some functions of the family, the equalizing function of education spending becomes relevant.

Finally, the results concerning the importance of headmaster's qualifications are rather unexpected. Headmaster's experience (years of service as school director) is irrelevant for student achievements, but whether he/she has a degree is significant, and impacts students

results negatively. This probably reflects some weakness of data, partly related to the fact that latest available information on teachers education was from 2000, that is two years before the school test investigated in this article took place.

**Conclusions and recommendations**

Our analysis showed that there are indeed two conflicting influences on student achievements related to school size. A very small school finds it difficult to use its resources effectively, especially teacher and space resources, however when the school size becomes excessive the negative effects appear, probably due to poor control over student behavior and learning, inability to adjust the curriculum and instructional methods to students needs etc. When the student specific factors (SES and similar) and the school specific factors (teacher qualifications and similar) are controlled, the average student outcomes initially improve as school size grows, and then begin to decline (see Figure 1). The optimal size of Polish primary schools (for the whole sample) seems to be about 690 students of the whole school, and about 120 students in the final sixth grade. This means that most of Polish primary schools are on the increasing part of the curve, and some degree of consolidation would be beneficial. On the other hand, there are also primary schools with an excessive number of students for effective functioning of the school.

Nevertheless, more detailed analysis shows that the optimal size of the school depends on many factors related not only to the school itself, but also to the social environment in which it operates. Indeed, we have shown that the optimal size of a primary school is much smaller in poorer local governments (under 600) than it is in affluent ones (over 900). We may therefore expect the effective rural schools to be significantly smaller than urban ones. The analysis of a larger sample (not restricted to the Mazowsze region) would probably show even more variation in the optimal school size due to local characteristics (for instance, the level of schooling of the local population). This implies that the consolidation process cannot be uniform across the country, but that each community must weight its special conditions to determine the optimal network of its primary schools.

Our research, in line with some of the studies cited in the introductory chapter, did not reveal strong, significant impact of class sizes on student achievements. In other words, in their search for improvement of school outcomes, the local governments should not pursue policies directed at either increasing or decreasing the class size (such policies have more financial than outcome related goals). We noted, however, that for large schools there is some negative impact of large classes, and this impact become more pronounced the larger the school becomes. This means that for large urban primary school, if the policy option of dividing them into smaller organizational units is for a number of reasons not practicable, the proper advice would be to decrease the sizes of classes, especially of 6th grade classes.

Finally, we have found a negative impact of long distance busing on average outcome of the whole school community (including both bused and 'local' students). It is important to stress, that it was the average distance traveled by transported students that showed to affect school performance more significantly than the number (share) of students being bused. Thus, consolidation may have worse effects on the functioning and performance of remaining schools if it involves an excessive increase of their catchment areas.

The limitations of our dataset (no data on individual students) preclude more careful analysis of direct and indirect effects of busing. The observations we made suggest however that in any consolidation policies a difficult trade-off must be made. On the one hand, most rural schools have small sizes and consolidation leading to their increase may hopefully result in improvements of the students outcomes. On the other hand, transporting students from far away will in general depress the test results. Thus from the point of view of the effectiveness of schools, that is of their ability to teach well and to allow their graduates to compete with graduates of urban schools, irrespective of cost considerations, the local governments are faced with a very difficult balancing choice. At present, no detailed analysis of this trade-off between increasing school size and transporting students from far away exists to help local governments make correct choices. This remains one of the key challenges to researchers working on the school production function in Poland.

**Bibliography**

Akerhielm, K. (1995). Does Class Size Matter? *Economics of Education Review*, vol. 14 No 3, 229-241

Andrews, M., Duncombe W., Yinger J. (2002). Revisiting economies of size in American education: are we any closer to a consensus?. *Economics of Education Review, 21,* 245-262

Coleman J., Armor D., Crain R., Miller N., Stephan W., Walberg H., Wortman P. (1966), Equality of educational opportunity, US Government Printing Office

Driessen, G. (2002). School composition and achievement in primary education: A large-scale multilevel approach. *Studies in Educational Evaluation* 28, 347-368

Falk A., Ichino A. (2003). Clean Evidence on Peer effects, working paper, University of Zurich, European University Institute

Fox, M. (1996). Rural Transportation as a daily constraint in students' lives. *Rural Educator, 17*(2), 22-27

Friedkin, N., Necochea, J. (1988). School system size and performance: A contingency perspective. *Educational Evaluation and Policy Analysis, 10*(3), 237-49

Hanushek E.,A.(1986). The economics of schooling: Production and efficiency in public schools, Journal of Economic Literature (24) 1986, 1141-1177

Hanushek, E.,A. (1996). School Resources and Student Performance in Gary Burtless, ed., Does Money Matter? The Effects of School Resources on Student Achievement and Adult Success. Brookings Institution, Washigton, D.C., pp.43-73

Hanushek, E., A., Kain, J.,F., Markman, J.,M., Rivkin S.,G. (2001). Does peer ability affect student achievement? *NBER working paper* No. 8502

Hanushek, E., A., Kain, J.,F., Rivkin S.,G. (2002). New Evidence about Brown vs. Board of Education: the Complex Effects of School Racial Composition on Achievement. *NBER working paper* No. 8741

Herbst, M., (2004). Human capital formation in Poland. Where does educational quality come from*?*, *DISES working paper no 99*, Universita degli Studi di Trieste

Herczyński J. (2003). The Financing of Georgian Education. *Problems of Economic Transition* (45) No. 10, 5-57

Herczyński J., Herbst M. (2002). Pierwsza odsłona. Społeczne i terytorialne zróżnicowanie wyników sprawdzianu szóstoklasistów i egzaminu gimnazjalnego przeprowadzonych wiosną 2002 roku, (Spatial and social differentiation of school outcomes in Poland)*, Fundacja Klub Obywatelski*, Warsaw

Howley, C. (1994). The academic effectiveness of small-scale schooling, ERIC Digest, *ERIC Clearinghouse on Rural Education and Small Schools* (ERIC Document Reproduction service No. ED 372 897)

Howley, C.B., Bickel, R. (1999). The Matthew project: National Report. *ERIC Document Reproduction Service No. ED 433 174*

Howley, A., Howley, C. (2001). Rural School Busing. ERIC Digest, ERIC Clearinghouse on Rural Education and Small Schools, EDO-RC-01-7

Howley, C., Strange, M., Bickel, R. (2000). Research About School Size and School Performance in Impoverished Communities. *Eric Digest. ERIC Clearinghouse on Rural Education and Small Schools*, EDO-RC-00-10

Hoxby, C. (2000). The Effects of Class Size on Student Achievement: New Evidence from Population variation. *The Quarterly Journal of Economics 115 (4)* 1239-1285

Hoxby, C. (2000a). Peer Effects in the Classroom: Learning from Gender and Race Variation. *NBER Working Paper* No. 7867

Imsher, K. (1997). School Size. ERIC Digest. ERIC Document Reproduction Service No. ED 414 615

Lee J.W., Barro R.J. (1997). Schooling quality in a cross-section of countries, *NBER working paper* 1997

Lee, V., Smith, J.(1996). High school size: Which works best and for whom? *Educational Evaluation and Policy Analysis, 19(3)*, 205-27

Lu, Y-C., Tweeten, L. (1973). The impact of busing on student achievement. *Growth and Change 4*(4), 44-46

Raywid, M.A. (1999). Current Literature on Small Schools. ERIC Digest. ERIC Document Reproduction Service No. ED 425 049

Strand, S. (1998). A "value-added" analysis of the 1996 primary school performance tables. *Educational Research, 40*(2), 123-137

Thrupp, M., Lauder, H., Robinson, T. (2002). School composition and peer effects. *International Journal of Educational Research, 37*, 483-504

Vidgor, J., Nechyba T. (2004). Peer Effects in North Carolina Public Schools. Paper for the CESifo/PEPG Conference on Schooling and Human Capital Formation in the Global Economy

Wößmann and West (2002) Class Size Effects in School Systems Across the World: Evidence from Between-Grade Variation in TIMMS, *IZA Discussion Paper 458*