Chapter 11
A Cost Model of Schools: School Size, School Structure and Student Composition

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11.1. Introduction

This chapter analyses the relationship between school resources and school and student body characteristics. School mergers and school district consolidation have been a controversial issue in several countries, including the United States, United Kingdom and Norway.[1] To have measures of financial benefits of such policies one needs estimates of the economies of scale in education. The available literature indicates sizable potential cost savings of consolidation, see for example Andrews et al. (2002) and Taylor and Bradley (2000). A separate argument, why economies of scale in education are important, is the existence of maximum class size rules, which is common in many countries. A reduction in the number of students does not necessarily affect the number of teachers simply because it does not need to affect the number of classes.

State aid to school districts typically tries to take not only objective cost differences into account, related to scale economies, but also differences due to variation in student composition. Students from certain demographic groups, for example students from ethnic minorities, may be more costly than other students, and it is usually argued that school districts with a large share of these types of students should for equity reasons be compensated with higher state aid, see for example Downes and Pogue (1994)

[1] In Norway the issue of school mergers has for some time been more controversial than the issue of school district mergers.

N. C. Soguel and P. Jaccard (eds.), Governance and Performance of Education Systems, 247–265.
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and Ladd and Yinger (1995).[2] In order to do so, one needs measures of the economies of scale and the extra costs related to specific groups of students. In addition to these cost and demand arguments, in several countries, national legislation gives students with special needs and students from ethnic minorities legal rights to extra resources. For instance, according to the Norwegian legislation, students whose parents speak a foreign language have the right to additional language instruction until they have a good command in the Norwegian language.[3] However, the extent to which such legal requirements for special groups of children are fulfilled or implemented will typically vary between school districts due to the budgetary situation, priorities within the local political entity and the political power of the parents representing these special groups of students.

With reference to the arguments above, a common question is: What does it cost to deliver a given level of education to our children? And related to student composition: What does it cost to bring certain demographic groups to reach a certain level of education? While simply framed, in reality, such questions are very hard to answer. A natural point of departure for an economist is to use a "cost function" approach. Assuming an underlying well defined production technology and that school owners minimize costs for every output level, a structural cost function relating total costs to input prices and output, and possibly exogenous environmental factors as school size and student composition, can be established. Such a relationship will describe how much it will cost to increase student performance.

Several problems arise when trying to establish such a relationship in education. First, how is output defined? A conceptually important distinction was introduced in the seminal paper by Bradford et al. (1969). They distinguish between services directly produced (D-output) and results of primary interest for the users (C-output). Within education, C-output can be defined as the level of valuable skills acquired by the students or the competencies paid off in the labor market, while D-output for example can be defined as the effective numbers of hours with learning in schools.

The problem is that C-output, in contrast to D-output, is not easily observed. Bradford et al. (1969) considered C-output to be at least partly determined by D-output and discuss whether measures of D-output can be

[2] Falch et al. (2005) provide a discussion for Norway.

[3] More details on the system in work up until 2003 can be found in Bonesrønning et al. (2005).

used as proxies of C-output.[4] This illustrates that it is not easy to estimate underlying structural parameters of educational costs and production. In a cost function approach the effect of output level on costs is of interest, while in a production function approach the effect of inputs (which determines the costs) on output is of interest. Strong assumptions are needed in order to empirically distinguish between cost function parameters and production function parameters. The output level is endogenous in the cost function. In addition, it is reasonable to consider education as producing many kinds of skills, and the output is therefore multidimensional. A cost function must include all outputs if it shall describe a cost-minimizing production process.

Further, it is by no means clear that the school owners' objective is to produce skills in a least cost way as assumed in the cost function approach. Several authors suggest that public-sector agents have other objective functions than simply cost minimization, following the seminal contribution by Niskanen (1971). One interpretation of the weak link between resource use in schools and student achievement is that the schools do not simply seek to maximize outputs, see for example Hanushek (2002). Accordingly, papers that try to estimate cost functions often get small and insignificant effects of output on costs, see for example Downes and Pogue (1994) and Duncombe and Yinger (2005), indicating that costs must increase considerably to achieve a minor increase in student performance.

To cope with these problems, several authors have tried to derive cost function parameters from the estimation of what they call "expenditure functions", see for example Ratcliffe et al. (1990) and Downes and Pogue (1994). The expenditure function is a reduced form model in the sense that determinants of school outputs are included in the model instead of the outputs themselves. However, the identification of underlying cost parameters from this approach requires strong assumptions about the political process transforming individual demand into community demand for education. In most countries, allocation of resources is taken by local governments subject to various restrictions given by the central authorities. In Norway, the local governments allocate the budget between several sectors such as education, health care and technical infrastructure. This allocation depends on income, the preferences of the local decision makers (politicians) and on the unit costs of services provided by the different sectors.

[4] On a more basic level, outputs are determined by inputs. Purchased inputs in schools include for example teachers, buildings and teacher material, which can be summarized by total cost.

Thus, school expenditures in a district are determined both by cost factors and the demand for public school services. This implies that knowledge of the decision-making process in the school districts is necessary to identify the parameters of interest and to distinguish between demand and cost factors in an expenditure function approach, see the discussion in Downes and Pogue (1994).[5]

In this chapter, we use information at the school level from Norway to estimate the relationship between resource use, student composition and school size net of these confounding effects. In light of the discussion above, our estimated relationship cannot be interpreted as a cost function in the meaning of the traditional economic textbook because we do not include output into the model. Including output will introduce all the problems described above, making it very hard to interpret the estimated coefficients. Our model can be seen as a reduced form model in the sense that both costs and output are determined by the same factors.

Our contribution to the literature is that we condition in our empirical model on school district fixed effects, that is, we only utilize variation between schools within districts to estimate the effects of school size and student composition on resource use. All demand factors common for all schools in a district are differentiated out of the model. In effect, we are removing from the model the district-level role of policy decisions, local preferences, political power of parents representing special student groups and the priority of spending on schools in relation to other services in the district. Thus, an alternative interpretation is that we estimate how the school districts distribute a given school budget between the schools. In that sense, our model can be considered as an "allocation model".

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[5] Studies of the demand for school services include Poterba (1997), Falch and Rattsø (1997, 1999) and Grob and Wolter (2005). Analyses of school costs have to a large extent focused on the economies of scale in education, see Fox (1981) and Andrews et al. (2002) for reviews of this literature. The literature on school cost models can be divided into three groups. The first group includes papers that use school-level data within one large school district, see for example Summers and Wolfe (1976), Roza and Hill (2004). The second group consists of a small number of papers that use school-level data for multiple districts in the analysis, see for example Cohn (1969), Kenny (1982), Taylor and Bradley (2000), but none of these papers condition on school district fixed effects as in the present paper. The last group of papers uses data at the school district level, see for example Downes and Pogue (1994), Duncombe et al. (1995), Duncombe and Yinger (1997, 2005), Duncombe (2002) and Imazeki and Reschovsky (2003).

In Norway, the maximum class size rule was terminated before the school year 2003/2004. The idea was that teaching could be made more efficient when organized in a more flexible way, with larger student groups in some subjects than in other subjects. One reasonable hypothesis is that economics of scale in education became less important under the new flexible system. We will investigate whether this regulatory change affected the economics of scale in the allocation of the school budget across schools. To our knowledge, this article is the first to examine empirically the consequences on school resource use from removing a maximum class size rule.

Section 11.2 gives a short description of our methodology, while Section 11.3 presents the institutional setting for Norwegian schools and the data we will use. The empirical results are presented in Section 11.4. Within our allocation model we find that costs per student is diminishing within the whole range of school size in Norway. Further, we find that a minority student costs almost twice as much as an average student, while students with special needs cost more than twice as much as an average student. Section 11.5 offers some concluding comments.

11.2. Methodological Issues

The approach in this chapter is to consider the actual allocation of educational services and inputs across schools and to study how this distribution depends on school size and student composition. Even within such a reduced form approach, problems remain as to the identification of the causal effect from student demographics on the distribution of school resources.

Consider a stylized case where the local governments allocate the budget between several sectors. As an example, consider two local governments, A and B, with an equal number of students to be given compulsory schooling. Both local governments are restricted by a maximum class size rule, say 30 students. In A, the students are distributed between two schools while in B, the students are distributed between five schools because of exogenous topographical reasons. The lower average school size in B implies that the necessary resources in terms of teachers are higher than in A simply because B is less able to fill up the classes to the maximum allowed.

Since the average class size is smaller in local government B than in local government A, the unit cost of education is higher in B than in A. Higher unit costs give, all else equal, B incentives to spend less on education than A for a given overall budget. In addition, the budget and spending decisions will depend on local preferences and the political power of different interests, including parents representing special student groups. Thus, the resulting distribution of resources across schools in different local governments may arise as a mixture of exogenous topographical and demographic factors, local preferences and the local decision-making processes.

To provide a more systematic discussion of the empirical challenges, consider a linear equation relating school resources *C* in school *i* in local government *j* at time *t* to school size *Q*, student composition *P* and a vector of variables at the school district level *Z*:

$$C_{ijt} = a_0 + a_1 Q_{ijt} + a_2 P_{ijt} + a_3 X_{ijt} + a_4 Z_{jt} + u_{ijt} \quad (11.1)$$

If we want to isolate the effect of school size on *C* from the exogenous demographic factors, we need to specify the vector *Z*. This is not an easy task given the complex and, for the researcher, unknown way local preferences are translated into local decisions through the political process. If omitted elements in *Z* are correlated with the school-specific variables *Q* or *P*, the estimated effect of these variables will be biased away from their true value.

Our way of handling this problem is to substitute *Z* with time-varying local government fixed effects as in Eq. 11.2:

$$C_{ijt} = a_0 + a_1 Q_{ijt} + a_2 P_{ijt} + F_{jt} + v_{ijt} \quad (11.2)$$

The fixed effects *F* control for all omitted variables at the local government level which affect school resources at particular schools. This model is therefore better suited than Eq. 11.1 to obtain unbiased estimates of the causal effects of school size and student composition on the allocation of resources across schools. Thus, in the empirical part of the chapter several versions of the basic model outlined in Eq. 11.2 will be estimated. As a robustness check, we also estimate a version of the model with fixed school effects.

11.3. Institutions and Data

Primary schools (grades 1–7) and lower secondary schools (grades 8–10) in Norway are run and owned by multipurpose local governments.[6] Private schools do not provide a realistic alternative to public schools because less

[6] The local governments are multipurpose institutions that provide other services in addition to schooling, for instance elderly care, day care and preschool educa-

than 3% of the students are enrolled in private schools. The number of schools varies to a great extent within the school districts (from 1 to 124) because of variation in population size and settlement pattern. Parental school choice between public schools for given residence is not allowed. Most schools are primary schools because lower secondary schools tend to include more students at each grade. About 25% of the schools are so-called combined schools which offer both primary and lower secondary education.

Before the school year 2003/2004, the maximum class size rule was removed from the school law and replaced by the following formulation: “Students can be divided in groups by requirements. The groups cannot exceed a level that is justified by pedagogical or security arguments” (§2.8 in the school law). One issue in this chapter is to investigate to which extent this change in the law changed the way resources are allocated across schools.

Usually accounting data are not available at the school level, but only at the school district level. This is also the case in Norway. Instead of using total costs, we use measures of the amount of teacher input, which accounts for about 70% of the total costs. We use school-level data from the Norwegian Ministry of Education which cover the school years 2001/2002–2005/2006. As a measure of resource use in the schools we will mainly use teacher hours per student. Teacher hours is a measure on how many hours the teachers interact with students, either in the classroom or as extra education to specific students (mostly disadvantaged students and minority students). Teacher hours can be regarded as the most accurate measure of the teacher resource use in schools.

Table 11.1 presents a descriptive overview of teacher hours per student as well as the teacher–student ratio. The number of schools (observations) slightly declines over time because of some school mergers. Teacher hours per student declined in the school year 2003/2004, thereafter stabilizing at an intermediate level. The same is true for the teacher–student ratio. The standard deviation is relatively large, indicating large variation across schools. The relationship between teacher hours per student and the teacher–student ratio is strong, the correlation coefficient is equal to 0.94, and is illustrated in Fig. 11.1.[7]

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tion and infrastructure. Spending on education consists of about 30% of total spending.

[7] Below, we will present empirical results only for teacher hours per student. Results using the teacher-student ratio as alternative dependent variable are very similar.

Table 11.1. Teacher hours per student and teacher–student ratio

	Teacher hours per student			Teacher–student ratio		
Year	Mean	Standard deviation	Observations	Mean	Standard deviation	Observations
2001/2002	84.3	28.4	3069	0.099	0.034	3070
2002/2003	84.3	29.6	3054	0.097	0.035	3058
2003/2004	82.6	28.4	3008	0.093	0.032	2977
2004/2005	83.8	28.2	2987	0.094	0.031	2993
2005/2006	83.7	28.5	2944	0.094	0.032	2948

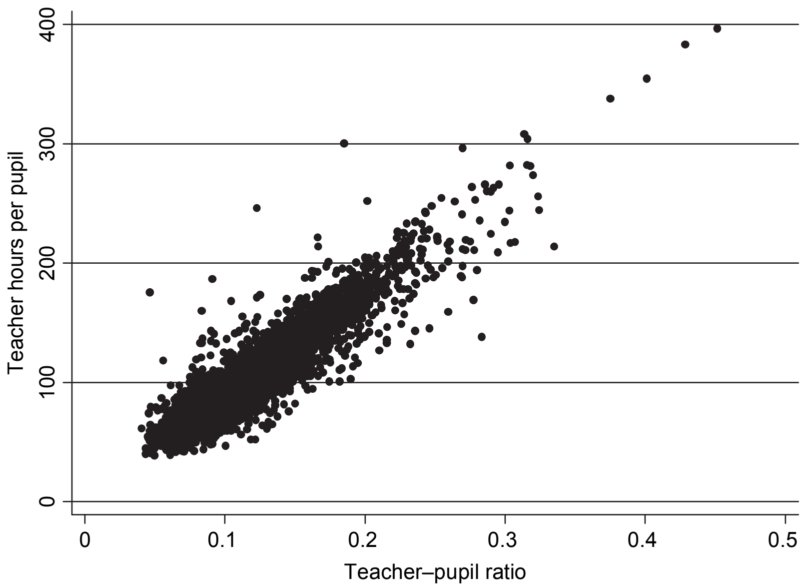

Fig. 11.1. The relationship between teacher hours per student and the teacher–student ratio.

The large variation in resource use per student across schools is related to variation in school size. The relationship between school size and resource use is illustrated in Fig. 11.2. In the figure, the first group of schools consists of schools with 10–19 students, the next group of schools has 20–29 students and so on.[8] The figure illustrates that Norwegian

[8] Schools with less than 10 students are excluded from the figure and the analysis below.

compulsory schools are relatively small and that the largest schools have about 800 students. Only about 0.6% of the schools have more than 600 students, and average school size is about 200 students.

Figure 11.2 shows that the resource use per student is clearly negatively related to school size, but with a diminishing rate. Economies of scale seems to be most important for schools up to about 300 students, but the resource use is lowest for schools with more than 600 students.[9]

Table 11.2 presents descriptive statistics for the two variables of student composition we will focus upon. While the share of students with special needs is relatively stable around 6% in the empirical period, the share of minority students increases every year and is close to 5% in the school year 2005/2006. Only students with extra education in Norwegian language are included in our definition of minority students in the present chapter.

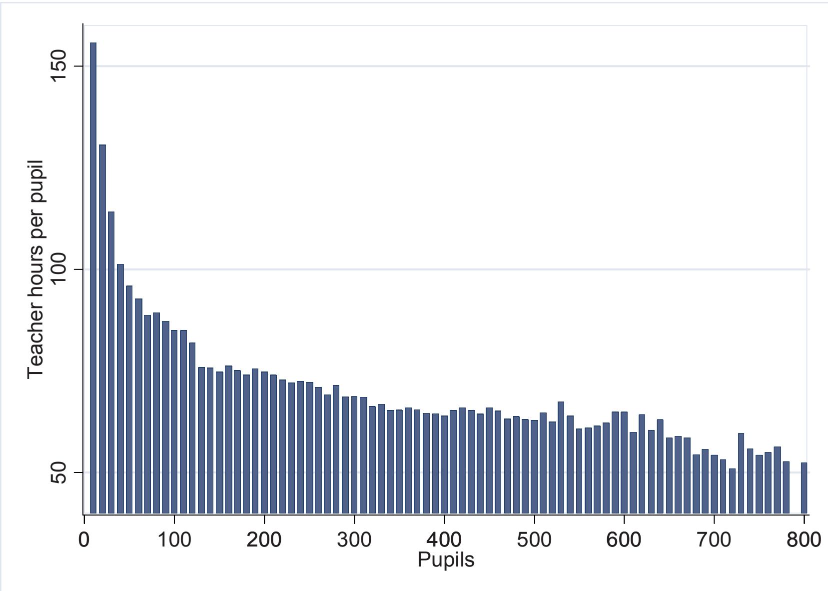

Fig. 11.2. The relationship between teacher hours per student and school size.

[9] Since there are relatively few schools with more than 600 students, Fig. 11.2 is based on data for all school years 2001/2002–2005/2006.

Table 11.2. Student composition

	Share of minority students			Share of students with special needs		
Year	Mean	Standard deviation	Observations	Mean	Standard deviation	Observations
2001/2002	0.039	0.071	3073	0.057	0.039	3065
2002/2003	0.041	0.074	3059	0.059	0.041	3060
2003/2004	0.043	0.080	3027	0.060	0.040	3028
2004/2005	0.045	0.081	2995	0.060	0.041	2995
2005/2006	0.047	0.085	2949	0.060	0.040	2949

In order to take into consideration that most resources may be delegated to students in lower secondary schools because they spend more hours at school per day than students at primary schools, we will include control variables for the share of students at the different grades. Variation in these shares will to a large extent reflect whether the school is a primary, lower secondary or a combined school, but dummy variables for primary school and lower secondary school will also be included in the model.

11.4. Results

We start out concentrating on the parameterization of the effect of school size. Columns A–D in Table 11.3 presents the results for different specifications of the relationship between resource use and school size, leaving out all other variables except the school district year-specific interaction effects. Considering the within-year within-school district explanatory power, the specification with the number of students squared (column A) performs relatively badly, while the specification with the logarithm of the number of students squared (column B) explains much more of the variation in resource use. The latter model indicates an optimal school size of about 400 students, which does not seem to be in agreement with Fig. 11.2. Thus, the next models presented apply functional forms without an optimum. While the explanatory power of the model using the inverse of the number of students (column C) is slightly lower than the model using the log of the number of students, that is not true for the model using the inverse of the squared root of the number of students (column D). However, the difference in explanatory power between these three models is small.

Table 11.3. Results of basic model formulations

Variable	A	B	C	D	E	F
Number of students	–0.256 (22.3)	–	–	–	–	–
Number of students squared/100	0.032 (15.3)	–	–	–	–	–
Log(number of students)	–	–82.0 (19.6)	–	–	–	–
Log(number of students) squared	–	6.87 (16.0)	–	–	–	–
Inverse of number of students	–	–	1171 (30.7)	–	–	–
Inverse of the square root of number of students	–	–	–	360 (35.2)	402 (38.9)	408 (45.9)
Share of minority students	–	–	–	–	64.3 (11.2)	66.2 (11.8)
Share of students with special needs	–	–	–	–	109 (15.0)	98.3 (13.7)
Classes at primary level only	–	–	–	–	–14.7 (19.9)	–14.4 (6.45)
Classes at lower secondary level only	–	–	–	–	–6.32 (8.11)	–4.30 (1.15)
R^2 (within group)	0.328	0.526	0.520	0.526	0.669	0.691
Observations	15,062	15,062	15,062	15,062	15,050	15,050
Variables for the share of students at each grade included	No	No	No	No	No	Yes
Year-specific local government fixed effects	Yes	Yes	Yes	Yes	Yes	Yes

Depended variable is the number of teacher hours per student
Estimated by ordinary least squares. The data covers all schools in Norway for the school years 2001/2002–2005/2006. *t*-values in parentheses are corrected to take account of within-schooling clustering of errors.

The predictive power of models B and D in Table 11.3 are presented in Fig. 11.3 together with the nonparametric results. The nonparametric results are obtained by using dummy variables for each school size. Both models perform well in terms of predictive power, but the model in column D seems to fit better the resource use in the largest schools.

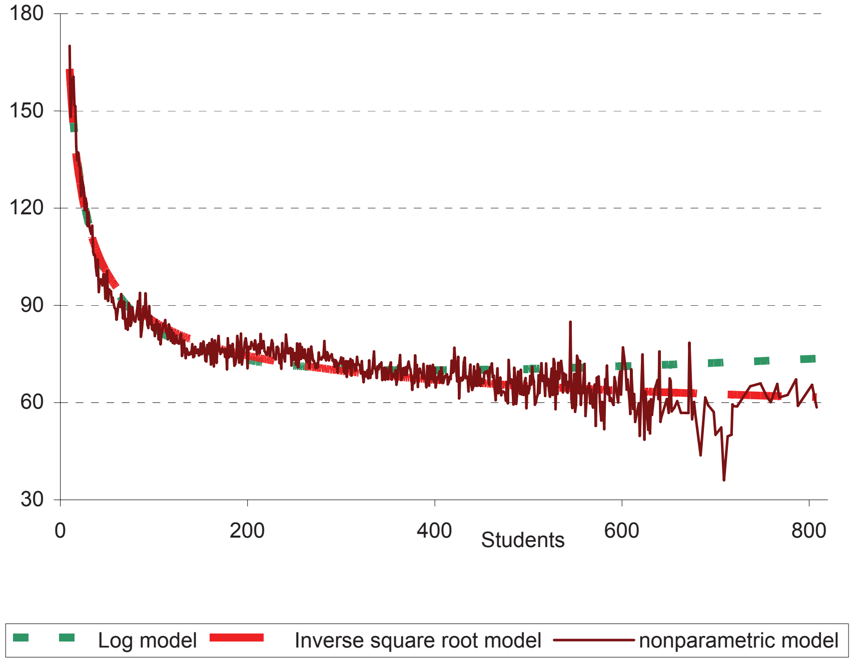

Fig. 11.3. Model predictions.

The lack of evidence of an optimal school size within our sample of relatively small schools is in accordance with findings for other countries. Andrews et al. (2002) review the literature on economies of size in the United States at the school district level and conclude that costs per student are minimized for about 2000–6000 students in the school district. For England, Taylor and Bradley (2000) use school-level data and find that the cost-minimizing school size is around 1600, which is about the size of the largest schools in England.

The estimated models imply large cost savings of school consolidation. The model in column D implies that the marginal effect of one new student when the school initially has 10 students is about –11. A reduction by 11 teacher hours per student is a large effect given that the average number of teacher hours per student is about 84. For initial school size of 200 (800) the marginal effect is still as large as –0.13 (–0.016). Further, the prediction of the model is that merging two schools with 50 (200) students reduces teacher hours per student by about 15 (7.5), that is 18 (9)% of the average resource use.

In the remaining analyses we use the specification regarding school size as in column D.[10] First, in column E in Table 11.3, we expand the model by including two measures of the student composition and dummy variables for whether the school is a primary school (1–7 grades) or a lower secondary school (8–10 grades).[11] All these variables have highly significant effects, but including them does not change the effect of school size to any large extent. The estimates indicate that a minority student costs on average about 64 teacher hours more than an average student, and a student with special needs costs on average about 109 extra teacher hours. Compared to average teacher hours per student, this is a major effect.

Primary schools have lower resource use per student than lower secondary schools, presumably because the students spend fewer hours per day at school. More surprising, lower secondary schools are slightly less costly than combined schools covering all grades.

Because the number of hours children spend at school per day increases with the grade, we include the share of students at each grade in the model in column F. This does not alter the results much, except that the dummy variables for school type are less precisely estimated as expected.

In Table 11.4 we undertake several robustness analyses. First, are the estimated coefficients stable across school types? In column A, we restrict the sample to include only primary schools, which is the largest group of schools. The estimated coefficients are close to the model including all schools, indicating that the results are reasonably stable across school types. However, there seems to be somewhat smaller economies of scale for primary schools than for other schools, and students with special needs costs about 10% more than estimated on the whole sample.[12]

One obvious reason for the economies of scale in teaching is the tradition to organize the students in classes. In Norway, as in many other countries,

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[10] The results by using the specifications in column B or C are very similar.

[11] The reference group is combined schools (1–10 grades).

[12] We have also estimated the same model for the sample of lower secondary schools and combined schools, respectively. Regarding lower secondary schools, the model is sensitive to whether schools with 10–20 students are included in the sample or not, even though there are very few lower secondary schools of this size. Regarding combined schools, the economies of scale are slightly larger than for primary schools, which is not surprising given that, for given number of students, there are fewer students at each grade. The cost of students with special need is estimated to be about 20% lower in lower secondary and combined schools than in primary schools.

Table 11.4. Results for alternative model formulations.

Variable	A	B	C	D	E
Inverse of the square root of number of students	363 (53.6)	409 (39.6)	406 (40.9)	543 (16.3)	437 (59.1)
Share of minority students	65.7 (15.1)	70.2 (14.9)	64.3 (8.96)	45.3 (5.00)	57.2 (12.8)
Share of students with special needs	111 (13.9)	84.8 (9.17)	107 (11.6)	64.6 (9.06)	94.0 (14.4)
Classes at primary level only	–	–15.4 (7.08)	–13.3 (4.87)	–7.69 (–3.29)	–20.6 (10.1)
Classes at lower secondary level only	–	–5.50 (1.59)	–4.29 (0.92)	–0.51 (–0.09)	–4.33 (1.24)
R^2 (within group)	0.710	0.699	0.690	0.210	0.750 (overall)
Observations	9,606	6,112	8,938	15,050	15,050
Variables for the share of students at each grade included	Yes	Yes	Yes	Yes	Yes
Year specific local government fixed effects	Yes	Yes	Yes	No	No
School fixed effects	No	No	No	Yes	No
Year-specific effects	Yes	Yes	Yes	Yes	Yes
Sample	Primary schools, 2001–2006	All schools, 2001–2003	All schools, 2003–2006	All schools, 2001–2006	All schools, 2001–2006

Depended variable is the number of teacher hours per student
Estimated by ordinary least squares. The data covers all schools in Norway for the school years 2001/2002–2005/2006. *t*-values in parentheses are corrected to take account of within-schooling clustering of errors.

there existed a national determined rule of maximum class size. A class could not exceed 28 students in the grades 1–7 and 30 students in the grades 8–10. Then, of course, there will be equally number of classes on a school with, say, 10 students at each grade as a school with 25 students at each grade, even though the last school is 2.5 times larger than the first school.

In 2003, the maximum class size rule was terminated in Norway. To investigate whether the more flexible system changed the allocation of resources across schools, columns B and C in Table 11.4 present separate regressions for the school years before and after the reform. Surprisingly, the economies of scale estimated are almost identical in the two periods. Also, the effect of student composition does not change much, although students with special needs seem to be somewhat more expensive and minority students somewhat less expensive in the latter period. But all together, the estimated relationship seems surprisingly stable over time.

One may speculate why the termination of the maximum class size legislation did not have a larger impact. One reason may be that the parliament when making the legislative change recommended, and even assumed, that the resource use in primary and secondary education should not be reduced as a consequence of the more flexible rules. Many school districts and also the Directorate for Education and Training have interpreted this wording as a recommendation for the local governments to leave the allocation of resources to each school unchanged. Then the legislative change could change the internal organization of instruction within schools, and our available casual evidence clearly suggests it has, while leaving the allocation rule of resources across schools unchanged.

Even though we condition on all aspects common for all schools within a local government a specific year, the results may be biased if there are relevant characteristics of the schools that are not included in the model. Schools may use different shares of their available resources on teachers because they, for example, differ in the demand for computers and new textbooks. Such factors may be correlated with the student composition.

To check the robustness of our model, column D in Table 11.4 presents results from a model including fixed school effects. These fixed effects capture all unobserved time-invariant characteristics of the schools. The results indicate that some important school-level variables may be missing in our baseline model. First, the economies of scale are even larger than in our baseline model. This result implies that changes in the number of students within a school over time have larger impact on the costs than differences across schools. Second, the effect of student composition is lower in the fixed school effects model. One interpretation is that the effect of student composition is overestimated when we do not control for unobserved time-invariant variables at the school level. Schools with a large share of minority students and students with special needs are allocated extra resources not only because these shares are high, but also for some unobserved reason. Another interpretation of the findings, however, might be that there is simply too little variation within schools over time in student composition to isolate the effects of student composition in a model with fixed school effects.[13]

It may be interesting to consider the differences between the local governments. In the models presented so far, we have only utilized variation within local governments or within schools. The model in column E in Table 11.4 excludes all fixed effects from the model and utilizes all the variation in the data (except across years). Interestingly, the estimated coefficients do not change much compared to the previous models. Both the economies of scale and the extra cost of minority students and students with special needs are of similar magnitude. This indicates that the differences in local school district expenditure policy are not much related to differences in school structure and student composition across school districts.

All the results presented in this section have used the number of teacher hours per student as the dependent variable. Table 11.5 presents similar models with the teacher–student ratio as the dependent variable multiplied by 1000. By this multiplication the two dependent variables have about the same mean and variance, and the estimated coefficients are reasonably comparable. The estimated coefficients are very similar as expected because the two dependent variables are highly correlated.

[13]The within-school standard deviations for the shares of minority students and students with special needs are both about 0.02. The overall variation is 0.08 and 0.04, respectively. Notice in particular that changes over time within school for the share of students with special needs may be due to variation in the treatment of one or a few students. Students that are on the margin of being classified as special needs students will typically get only a small amount of extra resources and may get extra resources some years but not others. If changes over time in the share of students with special needs are driven by such marginal students, the signal to noise ratio in the within-school data is probably low and hence the estimated effect would be biased downwards. In any case, we would expect to estimate a smaller effect compared to the baseline model where the identification is based on both between- and within-school variation in student composition.

Table 11.5. Results using an alternative dependent variable.

Variable	A	B	F	D	E	C
Log(number of students)	–84.2 (17.8)	–	–	–	–	–
Log(number of students) squared	7.13 (14.6)	–	–	–	–	–
Inverse of the square root of number of students	–	358 (29.2)	441 (45.6)	455 (36.6)	431 (40.6)	606 (15.2)
Share of minority students	–	–	71.7 (12.2)	80.8 (10.7)	67.4 (9.67)	28.3 (1.59)
Share of students with special needs	–	–	109 (12.5)	109 (10.4)	109 (10.3)	65.4 (7.55)
Classes at primary level only	–	–	–18.5 (8.01)	–23.4 (6.68)	–15.0 (4.55)	–9.22 (3.56)
Classes at lower secondary level only	–	–	–1.42 (0.37)	–1.42 (0.24)	–3.56 (0.64)	3.57 (0.84)
R^2 (within group)	0.390	0.389	0.668	0.675	0.670	0.216
Observations	15,046	15,046	15,034	6,117	8,917	15,034
Variables for the share of students at each grade included	No	No	Yes	Yes	Yes	Yes
Year-specific local government fixed effects	Yes	Yes	Yes	Yes	Yes	No
School fixed effects	No	No	No	No	No	Yes
Sample period	2001–2006	2001–2006	2001–2006	2001–2003	2003–2006	2001–2006

Depended variable is the teacher–student ratio times 1000
Estimated by ordinary least squares. The data covers all schools in Norway for the school years 2001/2002–2005/2006. *t*-values in parentheses are corrected to take account of within-schooling clustering of errors.

11.5. Conclusion

This chapter estimates an "allocation model" of school spending which describes how school districts allocate their school budgets across schools. We argue that this is the best possible way to analyze the cost structure of schools. We argue that it is inherently difficult to estimate a "cost function" that can predict how much it will cost to deliver a given level of student performance because researchers lack important information on school outcomes and the management and cost effectiveness of schools.

We focus on the effect of school size and student body composition on the amount of teacher resources allocated to schools using panel data on

Norwegian schools and local governments for the period 2001–2006. By using a fixed effect school district specification, we are able to estimate the model controlling for unobservable district variables that may affect the relationship via the demand for education and the political processes that determine school resource allocation.

Our results clearly suggest that the effect of school size is highly nonlinear. Thus, merging schools seems to be an important instrument in a cost-saving strategy in the school sector. However, the question of school consolidation also depends on the relationship between student performance and school size, a topic that has not been studied in this chapter. A positive (negative) relationship between school size and student performance would strengthen (weaken) the argument for a policy to stimulate school mergers. Our results coincide with studies from the United States and United Kingdom that cost-minimizing schools are large.

Our results also show a clear positive relationship between teacher hours per student and the share of students with special needs and the share of students from ethnic minorities. The point estimates indicate that on average 55–80% extra resources are allocated to minority students compared to "average" students, while 65–130% extra resources are allocated to students with special needs. The lower bond of these point estimates follow from a model including school fixed effects instead of school district fixed effects.

Finally, we investigated whether the removal of the maximum class size rule in 2003 changed the allocation of resources between schools. The evidence so far indicates that the reform did not have any significant effect on the allocation of resources. More future research is needed to determine whether the allocation changes in a longer run perspective and to which extent the reform affected student performance.

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