Efficiency Potential and Efficiency Variation in Norwegian Lower Secondary Schools

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The paper performs an efficiency analysis of lower secondary schools in Norway. The efficiency potential is calculated as 14%, based on a DEA analysis with grades in core subjects (adjusted for student characteristics and family background) as outputs. The analysis of the determinants of efficiency indicates that a high level of municipal revenue, a high degree of party fragmentation, and a high share of socialists in the local council are associated with low educational efficiency. The negative effects of the share of socialists and party fragmentation seem to reflect both higher resource use and lower student performance.

Keywords: educational efficiency, DEA analysis, determinants of efficiency, political and budgetary institutions

JEL classification: I 21

1. Introduction

The educational sector has received substantial attention in academic and political debate in recent years. International knowledge tests have provided new and easily accessible information that facilitates a comparison of educational performance across countries. A key finding is that the international tests indicate a negative correlation between student performance and resource use, meaning that the richest countries, which allocate the most resources to the educational sector, do not receive high achievement in return. Norway, which is a rich country with high resource use and (at

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best) average student performance, is no exception to this tendency. The mismatch between resource use and performance has triggered a political debate regarding resource use, curriculum, and the organization of the school sector. Measures have been taken to increase the number of hours in basic subjects, to provide better information on the performance of individual schools, and to open public schools to more competition from private schools.

The purpose of this paper is to analyze the efficiency potential in the lower-secondary-school sector in Norway. The efficiency potential is not identified by comparing Norway with other countries, but rather by comparing performance and resource use among Norwegian schools. Our aim is to calculate the gain that could be achieved if all municipalities operated their school sector according to the best Norwegian practice. The analysis is related to a large literature, starting with Bessant et al. (1982) and summarized by Worthington (2001), which applies data envelopment analysis (DEA) to the educational sector. To our knowledge this is the first DEA analysis of lower secondary education in Norway that uses grades or student achievement as outputs.[1]

With respect to the existing international literature, we make two contributions. The first relates to the handling of family background as an indicator of the quality of the students. We take advantage of a rich data set of more than 100,000 students containing grades and extensive information on family background to estimate a measure of student performance adjusted for variation in family background. It is these adjusted grades, rather than the raw grades, that are used as outputs in the DEA analysis. The advantages of this approach are that the inputs in the DEA analysis can be restricted to factors under direct control of the educational institution and that differences in family background are taken into account in the calculation of the efficiency potential. The second contribution is that we provide an extensive analysis of variation in efficiency scores along the lines of Duncombe, Miner, and Ruggiero (1997) and Grosskopf et al. (2001). We investigate the influence of political and budgetary institutions of the municipality, along with traditional variables like school size.

In Norway primary and lower secondary education is mainly a municipal responsibility, and the municipalities are the units of observation in this study. The DEA analysis reveals large variations in efficiency across municipalities, and the average efficiency potential is calculated as 14%. The variation in efficiency is analyzed using tobit regression, which indicates that a high level of revenue, a high degree of party fragmentation, and a high share of socialists in the local council are associated with low educational efficiency.

1 Bonesrønning and Rattsø (1994) analyze Norwegian high schools using grades as output.

The negative effects of the share of socialists and party fragmentation seem to reflect both higher resource use and lower student performance.

The rest of the paper is organized as follows: Section 2 provides the necessary institutional background. The principles of DEA analysis and the approach taken in this paper are discussed in section 3; section 4 discusses data and model specification. Section 5 presents the findings of the DEA analysis and discusses the robustness of the results. Section 6 is devoted to the tobit analysis of the determinants of educational efficiency. Finally, section 7 offers some concluding remarks.

2. Institutional Background

Most primary and lower secondary schools in Norway are owned and operated by the municipalities. Private schools account for less than 2% of the students, and until the school year 2003/04 the few private schools in operation were either religious schools or schools that use alternative educational methods. In 2003 the parliament passed a new law on private schools, which allows for nonreligious private schools that use traditional educational methods. This study is based on data for the school years 2001/02 and 2002/03 and only includes municipal schools.

Norwegian municipalities are multipurpose authorities that, in addition to education, are responsible for welfare services like child care, primary health care, and care for the elderly. Other important tasks are culture and infrastructure. The main revenue sources are taxes (43% of current revenue), block grants (21%), earmarked grants (13%), and user charges (16%). Interest and other revenue account for the rest. Since earmarked grants and user charges are practically nonexistent in primary and lower secondary education, the sector is mainly financed by taxes and block grants. Compared to most other countries, the system of financing is quite centralized. Around 95% of local taxes are regulated income and wealth taxes where effective limits on tax rates have been in place for the last 25 years. The opportunity to influence current revenues is limited to property tax and user charges.

The municipalities enjoy more discretion on the spending side than on the revenue side. The allocation of taxes and block grants between different service sectors is decided locally, subject to national regulations and minimum standards. In the educational sector there is a national curriculum, and minimum standards are determined by a maximum class size and minimum number of hours per class in each subject.[2] Moreover, until 2004 the teachers' unions negotiated wage and workload (teaching hours per week) with

2 From the school year 2003/04 the class size regulation was replaced by a more flexible regulation of group size.

the national government. Despite these national regulations, there is substantial variation in resource use per student between schools and between municipalities (see section 4). The variation between schools is to a large extent related to school size, and the variation between municipalities is related to the choice of school structure and thereby average school size. The settlement pattern, the number of students in the municipality, and the municipal revenue are important determinants of average school size. Few students and a decentralized settlement pattern tend to give small schools, and municipalities with high levels of revenue can afford a decentralized school structure with many small schools.

3. Data Envelopment Analysis

Over the last decades several methods have been developed to estimate production frontiers and the degree of efficiency for each unit of production. Today the two dominant approaches are data envelopment analysis (DEA) and stochastic frontier analysis (SFA).[3] The two approaches have different strengths and weaknesses. DEA is a linear programming method that has the advantage that no restrictive assumptions about technology (the functional form of the production function) or the distribution of efficiency have to be made, and that it easily handles multiple inputs and outputs. The main weakness of DEA stems from the fact that it is a nonstatistical method with no random error. As a consequence, it does not produce statistical tests and is sensitive to measurement error. SFA is an econometric approach that allows for statistical testing and is less sensitive to measurement error, but requires the researcher to impose a specific functional form of the production function and make strong assumptions about the distributions of the random error and the efficiency term.

There is no consensus in the literature on the choice between DEA and SFA, and both approaches are widely used in applied work. Hjalmarsson, Kumbhakar, and Heshmati (1996, p. 304) conclude that "the choice between different approaches must be based on trade-offs concerning the purpose of the study, type of data, technology characteristics, etc." In this paper we rely on DEA. The DEA method is attractive in our case because the knowledge of the functional form of the educational production function is limited and because the data set allows for multiple inputs and outputs. Moreover, our primary interest is to calculate and explain variations in educational efficiency, not to provide estimates of the educational production function.

3 De Borger and Kerstens (1996) and Hjalmarsson, Kumbhakar, and Heshmati (1996) provide comparisons of DEA and SFA.

The DEA approach was first introduced by Charnes, Cooper, and Rhodes (1978) in order to calculate relative technical efficiency in the case of multiple inputs or outputs in the production process of nonprofit actors, e.g., in the public sector. Technical efficiency is a normative concept and should be interpreted as the inputs or outputs compared to a standard or a norm, and the basic concept of the DEA procedure used in this paper is to minimize the level of inputs for a given amount of outputs.[4] This is done by simultaneously solving a linear programming problem for each unit (municipalities in our case). Generally municipalities will value their inputs and outputs differently and thus call for different sets of weights in the conventional measure of relative efficiency.[5] The efficiency of a single municipality is calculated relative to a *best-practice* reference frontier. This frontier is defined as a linear combination of the inputs and outputs of efficient municipalities in the sample. The weights and the efficiency measure for each municipality are identified simultaneously in the DEA procedure. As discussed above, the method requires no *a priori* specification of the functional form of the educational production function.

We will now illustrate the DEA procedure by considering a simplified educational sector where a single input (number of teachers per student) is used to produce a single output (student achievement). The simplification allows us to describe the production process in a simple two-dimensional diagram as in figure 1. The points A, B, C, and K represent locations of different municipalities in the input–output space.

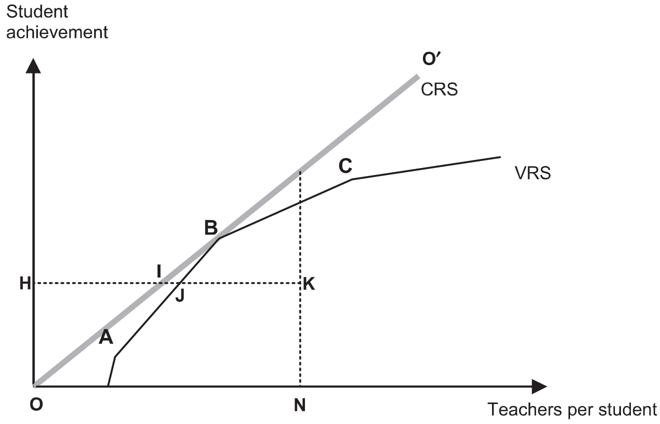
The DEA model originally proposed by Charnes, Cooper, and Rhodes (1978) was input-oriented and allowed only for constant returns to scale. This approach has since been widely developed; see, e.g., Banker, Charnes, and Cooper (1984), where a variable-return-to-scale specification was first proposed. We start out by considering the case with constant returns to scale. In figure 1 the efficiency frontier is then represented by the line OO' passing through the origin and observation B in the diagram.[6] Observation B lies on the reference frontier and is assumed to be fully efficient, while observations that lie below the line OO' (e.g., A, C, and K) are inefficient. Inefficiency implies that the observed units could have produced the same level of outputs with less input by using the best-practice technology defined by the reference frontier. A municipality is less inefficient the larger the

4 Alternatively the efficiency may be calculated by maximizing the outputs for a given level of inputs. In this paper we focus only on input-oriented technical efficiency.

5 Conventionally, relative efficiency is calculated as the ratio of weighted outputs to weighted inputs with a common set of weights.

6 On drawing a line from the origin through each sample observations in figure 1, the line passing through observation B has the greatest slope. Observation B is the most productive of the sample observations. All the other observations lie below this line.

Figure 1
The Best-Practice Reference Frontier under Constant and Variable Returns to Scale



distance to the frontier. In figure 1 the efficiency of observation *K* can be expressed as the ratio of efficient use of inputs to the actual use of inputs; this ratio is represented in the figure as the distance *HI* divided by the distance *HK*. For all observations situated below the efficiency frontier, this ratio will lie between zero and one, while for observation *B* (the efficient municipality) it is equal to one.

With variable returns to scale the reference frontier is represented by the piecewise linear curve passing through observation *A*, *B*, and *C* in figure 1. In this case only observation *K* is situated below the efficiency frontier and defined as ineffective. Given the output of municipality *K*, the efficient amount of inputs is represented by point *J*, and the relative efficiency (or efficiency score) is thus given by the ratio *HJ*/*HK*.

One characteristic of the DEA method is that the number of efficient units and the calculated efficiency potential depend on the number of inputs and outputs relative to the sample size. For a given sample size an increase in the number of inputs and/or outputs will increase the number of efficient units and reduce the calculated efficiency potential. It becomes important to formulate a proper model specification, since an overspecified model (with many outputs and inputs) may underestimate the efficiency potential, whereas an underspecified model (with few outputs and inputs) may overestimate it.

When the DEA method is applied to the educational sector, it is a challenge to limit the number of variables. It is well documented that socioeconomic variables capturing family background are important determinants of student achievement (e.g., Hanushek, 1986), and the potential number of relevant variables describing the quality of student input is very large. In applications of DEA to the educational sector this problem is dealt with in two different ways; see Coelli, Prasada Rao, and Battese (1998) and Worthington (2001). The first is a two-stage procedure where only factors under direct control of the educational institution are included as inputs in a first-stage DEA analysis, and where variables capturing family background are included in a second-stage tobit regression. The problem with this approach is that the efficiency scores from the DEA analysis are biased because differences in family background are not taken into account.

The second alternative is to include variables capturing family background as inputs in the DEA analysis to get unbiased efficiency scores. However, if it is necessary to include a large number of socioeconomic input variables, the efficiency scores may be biased because the number of inputs and outputs becomes large relative to the sample size. The practical solution is to include a few variables or to construct an index of the socioeconomic environment (e.g., Duncombe, Miner, and Ruggiero, 1997). In this case the remaining question is whether family background is sufficiently controlled for.

In this paper we propose a third alternative, where we utilize a rich data set of more than 100,000 10th-graders containing information on grades, student characteristics, and family background. We estimate regressions with individual grades as dependent variable and variables capturing family background as explanatory variables. In addition, a full set of dummy variables for each municipality is included. The estimates of the municipal dummy variables, which may be interpreted as grades adjusted for family background, are used as outputs in the DEA analysis. The advantages of this approach are that the inputs in the DEA analysis can be restricted to factors under direct control of the educational institution and that a large set of variables describing family background can be taken into account in the calculation of the efficiency potential. Moreover, it is not necessary to decide *ex ante* whether each socioeconomic variable has a positive or a negative effect on achievement, as is necessary when the variables are included as inputs in the DEA analysis. A similar approach is used by Grosskopf et al. (2001), where output is based on value-added residuals from a regression with current test scores as dependent variable and previous test scores and the socioeconomic composition of the student body as explanatory variables. However, they do not use data for individual students and only control for a few socioeconomic characteristics.

Another potential problem is that the DEA method is sensitive to measurement error and outliers that tend to overestimate the efficiency potential. The reason is that outliers with high output and/or low input use will affect the position of the frontier and thereby reduce the efficiency score of other units. Outliers with low output and/or high input will only have a minor effect, since they only affect the average efficiency by making themselves less efficient.

In the empirical analysis we use adjusted grades as outputs. In small schools and small municipalities in particular, average grades may vary from year to year, reflecting (unobservable) variation in the quality of the student population. As a consequence the efficiency potential may be overestimated because the frontier is determined by the units with high-quality students. In the empirical analysis we try to reduce this problem by using data that is averaged over two school years. Controlling for student characteristics and family background, as discussed above, also contributes to reducing the problem of variation in student quality. In addition we perform jackknifing to investigate whether the results are sensitive to outliers and measurement error.

4. Data and Specification of the Educational Production Function

Most applications of DEA to the educational sector use grades or test scores as outputs, and in this study we follow that tradition. We take advantage of a national database with information on grades for individual students for the school years 2001/02 and 2002/03. The database provides information on individual assessment grades and exam result for students in the final year (10th grade) of lower secondary education. Written national exams are arranged in the three core subjects Norwegian, English, and mathematics, but each student is only examined in one subject. Even at the municipal level there are many cases where not all three core subjects are covered by national exams. Assessment grades have a wider coverage and are reported for 13 different subjects for each student.

Since the purpose of this study is to investigate variations in efficiency across municipalities, educational output is mainly measured by assessment grades, which are available for all municipalities. The assessment grades (in the final year) are high-stakes tests in that they are used for applications to the upper secondary level. Students therefore have incentives to put effort into home and class work. A possible weakness of assessment grades is that grading practice may vary between municipalities. We think this problem is smaller for the core subjects (Norwegian, English, and mathematics), where national exams are arranged, since the results on national exams represent important feedback to teachers that facilitate correction of divergent grading practices. In the benchmark model we therefore concentrate on assessment grades in the core subjects as indicators of educational output. Some descriptive statistics for the mean assessment grades are given in appendix table 7. Grades are given on a 1–6 scale where 6 is the best. In Norwegian the grade varies from 2.9 in the municipality with the lowest grade to 4.8 in the municipality with the highest grade, with a mean of 3.8. The mean grade is somewhat lower in mathematics than in Norwegian and English, but the variation across municipalities is of roughly the same magnitude in the three subjects.

Although we think assessment grades in core subjects are reasonably good indicators of educational output, we also formulate production functions with additional outputs. First, a possible problem with focusing on core subjects is that we may underestimate the degree of efficiency in municipalities where schools have devoted a large amount of effort and resources to other subjects. To take account of this possibility we formulate a model where the average grades in other subjects are included as an additional output. Second, variation in grading practices is a potential problem even when we focus on core subjects. To take this into account we also formulate a third model where the results of the written national exam are included as an extra output.

Table 7 also reports descriptive statistics for the average assessment grade in other subjects and results from the written national exam. It appears that the average grade level is higher in other subjects than in core subjects, and that the variation across municipalities is smaller. For the exam results the difference goes in the opposite direction: The average grade level on the written exam is lower than the assessment grades in core subjects, and the variation across municipalities is larger.

As discussed in section 3, we utilize a rich data set of more than 100,000 10th-graders to construct grades that are adjusted for family background. The data set contains individual assessment grades and information on socioeconomic background for all 10th-graders in the academic years 2001/02 and 2002/03. This rich data set enables us to adjust the grades for family background, and the adjustment is done by performing a regression of the following type:

$$y_{ijt} = \beta x_{ijt} + \gamma_t + \alpha_j + u_{ijt}\,, \tag{1}$$

where y_{ijt} is the assessment grade of student i in municipality j in school year t. The vector x captures student characteristics and family background, γ_t is a year-specific constant term, α_j represents municipal fixed effects, and u_{ijt} is an error term. The α's may be interpreted as the average grade in the municipality adjusted for family background.

Equation (1) is estimated for each of the three core subjects Norwegian, English, and mathematics, for the average grade of the remaining subjects, and for the results of the written national exam. The vector x contains variables that are typically used in analyses of student achievement. It includes a number of individual dummy variables on the student's gender, quarter of birth (given that they graduated in the year they turned 16), graduation earlier or later than expected, and whether they are immigrants or adopted. Family background is captured by parents' education and income (separate for the mother and the father) and dummy variables reflecting whether the parents are married to each other, cohabitants, separated, divorced, or none of these. We do not have information on whether individual students receive adapted teaching due to learning disabilities, only on the fraction of students at each school that receive such teaching. This fraction, labeled the fraction of students with special needs, is also included in x.

It should be noted that the estimated equation for the results from the national exam is slightly different from the estimated equations for the assessment grades. First, because the average grade level on the exam differs between subjects, it is necessary to include controls for whether the student has been examined in Norwegian, English, or mathematics. Second, we have tested for possible peer-group effects by including a variable describing the average level of education for the parents of the other students in the school. It turned out that such peer-group effects were present in the results from the national exam, but not in the equations for the assessment grades.

The appendix table 8 reports descriptive statistics for the x variables; the regression results are reported in table 9. The estimated coefficients in table 9 mainly serve to control student achievement for the available variables capturing family background, and to a great extent they confirm the findings from other analyses on the effect of family background on student achievement; see Hægeland, Raaum, and Salvanes (2004) for a recent Norwegian analysis, and Hanushek (2002) for a survey of international contributions. In brief, we find that parental educational level and income have positive and highly significant effects on student achievement, while immigrants have significantly lower achievement levels. Students living with both parents (either married or cohabiting) get higher grades than students living with only one of their parents (single, separated, or divorced). The estimated effect of the share of students receiving adapted teaching at the student's school is significantly negative and indicates that schools with a higher share of students with special needs have lower achievement level.

The average values of the estimated municipal fixed effects (the α's) are close to zero, and are not directly comparable to the original grades, which are on a 1–6 scale. They are made comparable by adding 3.5 to the α's.[7]

7 The municipal fixed effects also need to be transformed (to be greater than zero) in order to be used as outputs in the DEA analysis. By adding 3.5 this requirement is fulfilled.

Table 1
Descriptive Statistics for Adjusted Grades, Teacher Hours per Student, and the Fraction of Certified Teachers

	Mean	Coefficient of variation	Min	Max
Adjusted grades				
Norwegian	3.55	0.052	2.94	4.34
English	3.53	0.053	3.04	4.19
Mathematics	3.54	0.055	2.99	4.42
Other subjects	3.53	0.042	3.13	4.14
National exam	3.51	0.061	2.73	4.36
Teacher hours per student	96.2	0.279	61.3	226.2
Fraction of certified teachers	0.95	0.057	0.69	1.00

Notes: The figures are based on data for 426 municipalities. The reported means are unweighted averages.

These adjusted grades are reported in table 1. It appears that the variation in adjusted grades is slightly less than the variation in the original grades, which indicates that the adjustment has the expected effect: Municipalities with low grades and poor socioeconomic status are lifted up, whereas municipalities with high grades and good socioeconomic status are leveled down. We also observe that the differences in the coefficient of variation across subjects are reduced compared to the raw grades reported in table 7.

The input measures we use are based on the total number of teacher hours and the fraction of certified teachers (meaning that they have certified education for the relevant grade level). Table 1 documents a substantial variation in teacher hours per student across municipalities, from a low of 61 to a high of 226. On average only 5% of the teachers are noncertified, but in some municipalities up to about 30% of the teaching staff is noncertified.

Table 2 displays the correlations between grades and teacher hours per pupil and the fraction of certified teachers. It appears that the five output measures are positively correlated. The correlations between adjusted assessment grades are in the range 0.4–0.7. The correlations between the assessment grades and the results of the written exam are weaker. However, since the exam result is an aggregate of grades in the three core subjects, the correlation between the exam result and a single assessment grade may be misleading. It is more appropriate to consider the correlation between the exam result and the average assessment grade in the core subjects. This

Table 2
Correlation Matrix for Adjusted Grades, Teacher Hours per Student, and Share of Certified Teachers

	Norwegian	English	Mathematics	Other subjects	National exam	Teacher hours per student	Share of certified teachers
Norwegian	1.000						
English	0.603	1.000					
Mathematics	0.507	0.421	1.000				
Other subjects	0.688	0.619	0.610	1.000			
National exam	0.235	0.312	0.403	0.329	1.000		
Teacher hours per student	0.311	0.319	0.287	0.373	0.213	1.000	
Share of certified teachers	−0.079	−0.089	0.006	−0.078	0.085	−0.241	1.000

correlation is about 0.4, which is of the same order as the correlation between the assessment grades in English and mathematics. The fact that the correlations between the five outputs are clearly less than unity can be also be considered as support for our choice of using the DEA approach rather estimating an SFA model with a single output.

Teacher hours per student are positively correlated with adjusted assessment grades, whereas the fraction of certified teachers is only weakly correlated with the five outputs. The positive correlation between adjusted grades and teacher hours per student is consistent with the results of Hægeland, Raaum, and Salvanes (2004). They find a positive (but modest) effect of teacher hours per pupil on assessment grades after family background is controlled for.

As mentioned above, we use three specifications of the educational production function in the DEA analysis. They have the same specification of inputs, but differ in the specification of outputs. As student characteristics and family background are controlled for in the calculation of adjusted assessment grades, only factors under municipal control are included as inputs. The two inputs that are included are the numbers of teacher hours given by certified and noncertified teachers, respectively. In the benchmark model (A), adjusted grades in the core subjects Norwegian, English, and mathematics are used as outputs. In model B the average grade in other subjects is included as an additional output. Model B has the advantage that it has a more comprehensive output measure, but the disadvantage that grades in other subjects may be less comparable across municipalities due to varying grading practices. The third model (C) extends the benchmark model by including the results of the national exam as an additional output. The advantage of model C is that it includes an output measure (exam results) that is not subject to varying grading practice across municipalities. On the other hand, it has the disadvantage that the results of the national exam are based on results from different subjects.

In the DEA analysis the outputs are specified as the adjusted grades multiplied by the number of students, and the inputs as the total number of teacher hours by certified and noncertified teachers, respectively.[8,9] In all three specifications we allow for variable returns to scale (VRS). Moreover, we focus on input-oriented efficiency scores, because the number of students, which is an important element of the output measures, is largely beyond municipal control. The analysis is based on data for 426 (out of 434) municipalities.

5. Educational Efficiency: The Results of the DEA Analysis

Descriptive statistics for the efficiency scores from models A, B, and C are reported in table 3. In model A, where adjusted assessment grades in core subjects are used as outputs, the mean efficiency score is 0.78 when all municipalities are given equal weight. This means that the average municipality could reduce inputs by 22% without reducing measured output. The results are similar to the U.S. studies by Duncombe, Miner, and Ruggiero (1997) and Grosskopf et al. (2001). Duncombe, Miner, and Ruggiero calculate an average efficiency score of 0.76 in their study of New York State school districts, whereas Grosskopf et al. (analyzing public schools in Texas) find that inputs could be reduced by roughly 20% without reducing output. Kirjavainen and Loikkanen (1998) find average efficiency of 0.82–0.84 in an analysis of senior secondary schools in Finland.

Table 3
Descriptive Statistics for the Calculated Efficiency Scores

	No. of effective units	Mean (unweighted)	Mean (weighted)	Minimum	1st quartile	3rd quartile
Model A	19	0.784	0.860	0.424	0.707	0.873
Model B	20	0.787	0.864	0.424	0.708	0.878
Model C	21	0.793	0.869	0.425	0.716	0.879

8 As a consequence the formulation of the DEA models is slightly different from the illustration in figure 1.

9 The data on the teacher hours only distinguish between primary schools (1st to 7th grade) and lower secondary schools (8th to 10th grade). In the analysis the numbers of teacher hours and students refer to the lower secondary level.

It is the weighted average of the efficiency score (with the number of students as weights) that reflects the national efficiency potential. The weighted average is 0.86, which yields an efficiency potential of 14%. The calculated efficiency potential reflects substantial variation in efficiency score across municipalities. 19 out of 426 municipalities come out as efficient (with an efficiency score of 1), whereas the lowest efficiency score is 0.42. Around 25% of the municipalities come out with an efficiency score below 0.71, and another 25% have an efficiency score above 0.87.

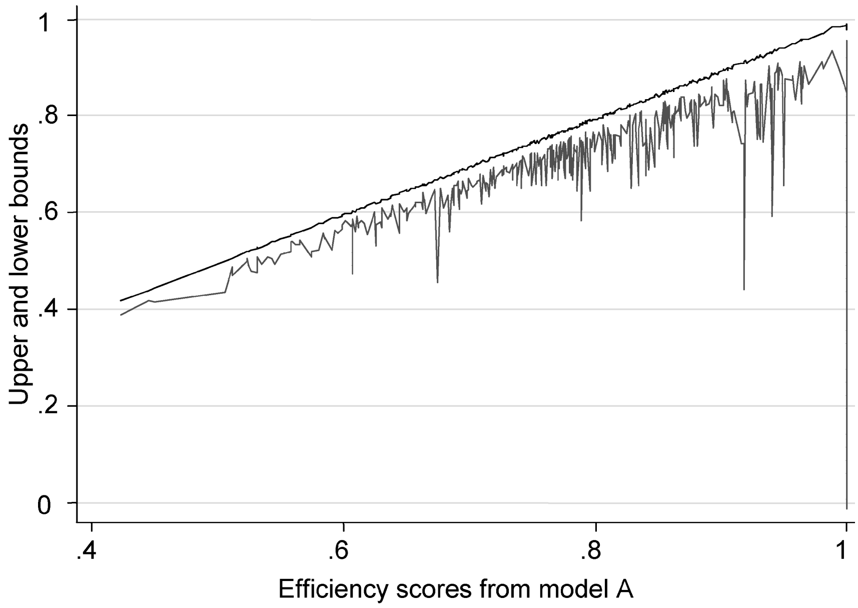
Model B, which includes average grades in other subjects as an additional output, gives more or less the same results as model A. The calculated efficiency potential is slightly reduced, from 14% to 13.6%. The ranking of the municipalities is also largely unaltered: the rank correlation is as high as 0.997. The robustness of the results indicates that high achievement in core subjects does not come at the expense of the achievement in other subjects, and that we do not lose much by focusing on the core subjects.

The results from model C, which includes the result from the written exam as an additional output, are also very similar to the results from model A. The difference in mean efficiency score is less than 1 percentage point, and the rank correlation is as high as 0.990. It might be argued that the high correlation reflects that the assessment grades are the dominating outputs in both models. We have investigated this possibility by comparing model A with a model where the exam result is the only input. Even in this case, where the two models have no common output, the rank correlation is as high as 0.92.

Although the reported quartiles (table 3) offer information about the variation in efficiency across municipalities, the DEA procedure does not provide us with any indication whether the calculated efficiency scores are significantly different between the municipalities. In recent years bootstrapped methods have been developed to calculate standard errors and confidence intervals for the efficiency scores; see Simar and Wilson (1998, 2000, 2004). We perform a smoothed bootstrap,[10] and the confidence intervals of the empirical distribution are obtained by drawing 2000 bootstrap samples. Upper and lower bounds for 95% confidence intervals for each municipality are shown in figure 2, where the municipalities are sorted according to the efficiency scores from model A. The midpoints of the confidence intervals are so-called bias-corrected efficiency scores that are outputs from the bootstrap procedure, where the bias reflects that the municipalities are now compared with a true frontier that lies above the usual DEA frontier. With a few exceptions the confidence intervals are narrow compared to the variation

10 The bandwidth is set according to the rule of thumb proposed by Simar and Wilson (2004).

Figure 2
Upper and Lower Bounds for 95% Confidence Intervals for the Bias-Corrected Efficiency Scores (Model A)



in the efficiency scores, and there are few overlaps between the intervals to the left of the figure and those to the right. Figure 2 can therefore be taken as evidence that the efficiency scores differ significantly across municipalities.

The bootstrap only provides information about the bias in efficiencies that is due to sampling error, and we have also investigated whether the results from model A are robust to measurement errors and outliers, by performing jackknifing. Jackknifing means that we leave out each efficient municipality one at a time. Then we run a new DEA analysis in each case. In our case with 19 effective municipalities, 19 additional DEA analyses are run. When one efficient unit is left out, the mean efficiency score of the remaining units will generally increase.[11] The efficiency scores are considered to be robust if the increase is small. In our case the increase in mean efficiency is 1 percentage point or less in 17 of the 19 cases. In the last two cases the increase is slightly above 1 percentage point. Moreover, the rank correlation between

11 The mean efficiency for the remaining units is unaffected if the unit that is left out is not a reference for any ineffective unit.

the original efficiency scores and the various jackknife models varies between 0.97 and 1.

Table 4 provides more information about grades and teacher hours per student in the efficient municipalities (from model A), and they are also compared with other municipalities with roughly the same number of students. The efficient municipalities are divided into three groups; (i) municipalities with 45–85 students, (ii) municipalities with 190–400 students, and (iii) municipalities with 700–1400 students. The table does not include the four smallest efficient municipalities and the three largest efficient municipalities, as they cannot be compared with inefficient municipalities with a similar number of students.

The four efficient municipalities in the group with 45–85 students (EM1–EM4) are characterized by both high grades and low resource use per student. Their grades are on average 3%–7% above the mean of all other municipalities in the group, and the number of teacher hours per student is 22% below. In the group with 190–400 students the best-performing municipalities (EM5–EM8) are also characterized by high grades and low resource use. Grades are on average 1%–5% higher than the mean of the group, and teacher hours per student 22% lower. In the largest group (700–1400 stu-

Table 4
Describing the Efficient Municipalities (Model A)

	Adjusted assessment grades			Teacher hours per student
	Mathematics	Norwegian	English	
Municipalities with 45–85 students				
EM1 (48 students)	3.59	3.61	3.91	85.3
EM2 (53 students)	3.67	3.46	3.64	91.8
EM3 (80 students)	3.78	3.85	3.85	88.2
EM4 (82 students)	3.81	3.89	3.95	98.5
Mean for the rest of the group	3.57	3.58	3.59	117.7
Municipalities with 190–400 students				
EM5 (196 students)	3.52	3.53	3.50	64.3
EM6 (201 students)	3.91	3.56	3.64	69.0
EM7 (252 students)	3.91	3.56	3.64	69.0
EM8 (388 students)	3.57	3.74	3.53	61.4
Mean for the rest of the group	3.52	3.53	3.52	85.0
Municipalities with 700–1400 students				
EM9 (704 students)	3.40	3.34	3.37	63.2
EM10 (835 students)	3.56	3.54	3.39	62.5
EM11 (905 students)	3.40	3.46	3.51	61.3
EM12 (1375 students)	3.41	3.43	3.63	72.4
Mean for the rest of the group	3.53	3.52	3.53	84.3

dents) the efficient municipalities (EM9–EM12) do not have higher grades than the mean of the group, but come out as efficient because they have low resource use per student.

The characterization of the efficient municipalities is different from Duncombe, Miner, and Ruggiero (1997). They find that efficient New York State school districts are characterized by high resource use (expenditures per student) that pays off in high student performance. In the Norwegian case, efficient municipalities are rather characterized by low resource use, but it is not associated with low student performance.

Finally, we have briefly compared the results from our approach with the approach where the variables describing family background are included as inputs in the DEA analysis. When all available variables are included in the DEA analysis, around 80% of the municipalities come out as fully efficient. We take this as evidence that the approach cannot handle a large number of socioeconomic variables without producing too many efficient units. Even when we restrict the socioeconomic controls to gender, parents' education, immigrants, and students with special needs, around 50% of the municipalities come out as efficient.

6. Explaining Variation in Educational Efficiency

As noted by Worthington (2001, p. 265), efforts to explain variation in educational efficiency are underdeveloped. Most studies merely compare efficiency scores in different groups of the sample. Duncombe, Miner, and Ruggiero (1997) and Grosskopf et al. (2001) are two of the few studies that attempt to explain variation in educational efficiency. They focus on monitoring and competition between school districts. In this section we try to explain variations in educational efficiency along the lines of earlier studies of efficiency in Norwegian municipalities that focus on political and budgetary institutions. The earlier studies include Kalseth and Rattsø (1998), who analyze administrative spending, Kalseth (2003), who analyzes the care for the elderly sector, and Borge, Falch, and Tovmo (2005), who analyze all service sectors simultaneously.

With regard to political institutions, several studies of Norwegian municipalities have emphasized the importance of political strength. There is evidence that political strength contributes to lower user charges (Borge, 2000) and to lower budget deficits (Borge, 2005). One interpretation of these findings is that a strong political leadership has an advantage in opposing pressure from external interest groups to increase spending (which in turn has to be financed by higher user charges and/or higher budget deficits). Moreover, political strength reduces administrative spending (Kalseth and

Rattsø, 1998) and increases efficiency (Kalseth, 2003; Borge, Falch, and Tovmo, 2005), which indicates that a strong political leadership also has an advantage in opposing internal pressure to increase budgetary slack. A traditional Herfindahl index has been the most widely used indicator of political strength. The index is calculated as

$$HERF = \sum_{p=1}^{P} SH_p^2 , \quad (2)$$

where SH_p is the share of representatives from party p. The index takes the maximum value 1 when a single party holds all the seats in the local council; the minimum value $1/P$ is attained when the seats are equally divided among the P parties. The Herfindahl index is inversely related to the degree of party fragmentation in the local council and thereby positively related to strength. We expect the Herfindahl index to have a positive effect on efficiency.

In Norway the socialist camp is dominated by the Labor Party, while the nonsocialist camp is more fragmented. As a consequence, there is a positive correlation between the Herfindahl index and the share of socialists in the local council. Since we cannot rule out that socialist influence has an effect on efficiency, one could argue that it should be included in the analysis to get an unbiased estimate of the Herfindahl index. A more substantial argument is that earlier studies document that a large share of socialists is associated with high administrative spending (Kalseth and Rattsø, 1998), low efficiency in care for the elderly (Kalseth, 2003), and low overall efficiency (Borge, Falch, and Tovmo, 2005). A possible explanation for these results is that it might be harder for socialists to impose a hard budget constraint on service producers because they are more concerned about service quality

When it comes to budgetary procedures, we distinguish between centralized (top down) and decentralized (bottom up) procedures in the initial phases of the budget process. In a centralized budgetary procedure the head of the administration (for an administrative centralized procedure) or of the executive board (for a political centralized procedure) presents an overall budget proposal for each sector, and the sectors only work out specific details within themselves. In a decentralized or fragmented budgetary procedure, on the other hand, each sector works out its own budget proposals, while the head of the administration or the executive board coordinates an overall budget proposal to be approved by the local council. Tovmo (2006) finds that a centralized budgetary procedure contributes to lower budget deficits, while Borge, Falch, and Tovmo (2005) find no significant effect on overall efficiency. The budgetary variable is only available for 306 of the 426 municipalities included in this study.

The earlier studies (Kalseth and Rattsø, 1998; Kalseth, 2003; Borge, Falch, and Tovmo, 2005) also indicate that high levels of local government revenue are associated with low efficiency. The underlying argument may be that the service-producing agencies are able to take advantage of a rich sponsor to increase budgetary slack. As an indicator of municipal revenue we use local taxes and block grants per capita deflated by an index that captures varying cost conditions across municipalities. This revenue indicator is widely accepted as the most reliable indicator of differences in economic conditions across municipalities.

Existing evidence on the effect of school competition or school choice, either between public and private schools or between public schools, yields no clear-cut answers. Hoxby (2000) provides evidence that school choice induces greater school productivity in an analysis of U.S. metropolitan areas, whereas Fiske and Ladd (2001) find that parental choice has a negative effect on achievement in elementary schools in New Zealand. Most Norwegian municipalities apply a neighborhood school rule that limits the competition between public schools. However, some municipalities have introduced school choice. A recent survey, focusing on the introduction of new management tools, indicates that around 13% of the municipalities have introduced some form of choice between public schools. We construct a dummy variable for whether school choice is introduced or not. It is available for 245 of the 426 municipalities included in this study.

The determinants of educational efficiency are analyzed using tobit regressions. This is an appropriate method, since the dependent variable, the calculated efficiency score from the DEA analysis, is censored at 1. The regression results are presented in table 5, where we use the efficiency scores from the benchmark model A as dependent variable in the first six columns.[12] The first equation (I) disregards the possible effects of political and budgetary institutions discussed above, and is primarily a test of our method of controlling for family background. It includes the level of education in the municipality (measured as the fraction of the population with education above upper secondary level), the share of students with special needs, and the share of minority students. We follow earlier studies of educational efficiency in including average school size (linearly and squared). Finally, we control for structural differences between municipalities by including population size and the share of the population living in rural areas.

The level of education and the share of minority students come out as insignificant, which indicates that our approach of controlling for family

12 Table 10 reports descriptive statistics for the variables used in the tobit regressions.

Table 5
The Determinants of Educational Efficiency

Variable	I	II	III	IV	V	VI	VII	VIII
Level of education	−0.180 (1.26)							
Minority students	−0.386 (1.54)							
Students with special needs	−0.884 (5.15)	−0.794 (4.76)	−0.772 (3.64)	−0.600 (2.90)	−0.780 (4.37)	−0.780 (4.31)	−0.790 (4.42)	−0.846 (4.77)
Average school size (in 100)	0.086 (4.39)	0.102 (4.65)	0.109 (4.01)	0.107 (3.94)				
School size squared	−0.008 (1.75)	−0.011 (2.24)	−0.013 (2.14)	−0.013 (2.13)				
Population size (in 1000)	0.001 (2.53)	0.001 (2.35)	0.001 (1.48)	0.001 (2.59)	0.002 (3.91)	0.002 (4.42)	0.002 (3.90)	0.002 (3.75)
Rural	0.025 (0.89)	0.018 (0.68)	0.000 (0.01)	0.024 (0.73)	−0.078 (3.05)	−0.078 (2.93)	−0.080 (3.13)	−0.091 (3.61)
Municipal revenue		−0.042 (1.50)	−0.036 (1.07)	−0.033 (1.07)	−0.124 (4.54)	−0.124 (2.22)	−0.126 (4.60)	−0.129 (4.77)
Herfindahl index		0.323 (4.60)	0.356 (3.77)	0.198 (2.49)	0.201 (2.76)	0.201 (2.30)	0.199 (2.73)	0.190 (2.63)
Share of socialists		−0.142 (3.61)	−0.127 (2.46)	−0.091 (1.97)	−0.123 (2.93)	−0.123 (2.74)	−0.125 (2.97)	−0.125 (2.99)
Centralized budgetary proc.			−0.019 (1.13)					
School choice				−0.019 (0.94)				
No. of observations	426	426	306	245	426	426	426	426
Log likelihood	308.8	319.5	220.5	204.1	293.1	293.1	290.7	292.5

Notes: Tobit estimates with absolute *t*-values in parentheses. The dependent variable in columns I–VI is the efficiency scores from model A. The efficiency scores from model B are used as the dependent variable in column VII, and the efficiency scores from model C in column VIII. The *t*-values reported in column VI are based on bootstrapped standard errors.

background and student characteristics works well.[13] On the other hand, the share of students with special needs comes out as significant, and a large share of students with special needs is associated with low efficiency. The significant effect of the share of students with special needs might reflect the lack of data on the individual level (see section 4). School size has a significantly positive effect on efficiency, while school size squared has a negative effect. However, the effect of school size does not reflect economies of scale, since variable returns to scale are allowed for in the underlying DEA analysis. It

13 Both variables come out as highly significant when they are regressed on the efficiency score from a DEA model where the raw assessment grades are used as outputs instead of the adjusted assessment grades.

rather reflects that the variation in efficiency across municipalities is related to average school size, and more precisely that the variation is larger among municipalities with small schools. Population size comes out with a positive and significant coefficient, while the share of the population living in rural areas is insignificant.

In column II we include municipal revenue and the political variables as additional explanatory variables. The two political variables come out highly significant. The positive sign of the Herfindahl index means that municipalities with highly fragmented local councils tend to have low educational efficiency. The share of socialists comes out with a negative sign, indicating that socialist influence is associated with low educational efficiency. Municipal revenue comes out with a negative coefficient, but it is not statistically significant.

The dummy variables for budgetary procedure and school choice are included as additional regressors in columns III and IV respectively.[14] Neither of the two variables comes out as significant. Moreover, the sign and significance of the two political variables and municipal revenue are unaffected when we control for budgetary procedure and school choice.

Our findings that party fragmentation and the share of socialists in the local council have a negative and significant effect on efficiency and that the choice of budgetary procedure is of little importance are in line with earlier studies of efficiency in Norwegian municipalities. However, in contrast to the earlier studies, the analysis does not produce a significant effect of municipal revenue. One might suspect that the reason for this discrepancy is that a high level of revenue is associated with a decentralized school structure, and that the effect of revenue is captured by school size in regressions I–IV. The suspicion is confirmed by regression V, where we exclude the school-size variables. Then municipal revenue comes out as highly significant and with the expected negative sign. In addition, the settlement pattern (the share of population in rural areas) becomes significant, and the quantitative effect of population size increases. Our understanding of these changes is that municipal revenue, population size, and settlement pattern represent background variables that explain school structure and average school size. As a consequence, the statistical significance and quantitative effects of these variables are reduced when actual school size is controlled for directly.

In the final three columns in table 5 we investigate the robustness of the results. The point of departure is column V, where the school-size variables are excluded. The first robustness test, reported in column VI, investigates

14 In order to limit the reduction in sample size, we do not include both variables in the same regression.

whether the significance of the explanatory variables is robust to bootstrapping of the standard errors. It appears that the *t*-values based on bootstrapped standard errors are very similar to those based on the usual standard errors. The main exception is municipal revenue, where the *t*-value is reduced by half, but the effect of municipal revenue is still significant at conventional levels of significance. In the final two columns we use the efficiency scores from models B and C respectively. It turns out that the sign and significance of the explanatory variables remain unchanged from column V, and also that the point estimates are reasonably stable across the specifications. In fact, this is no surprise, given the high correlation between the efficiency scores from the two models.

We finally illustrate the quantitative effect of municipal revenue and the two political variables using equation V in table 5. An increase in municipal revenue that amounts to 10% of the mean is expected to reduce educational efficiency by 1.2 percentage points. An increase in party fragmentation by 10 percentage points is predicted to reduce efficiency by 2 percentage points. The predicted effect of an increase in the share of socialists by 10 percentage points is to reduce efficiency by 1.2 percentage points. Compared to the analysis of overall efficiency by Borge, Falch, and Tovmo (2005), the quantitative effects of municipal revenue and party fragmentation are weaker in our case.

In table 6 we investigate how party fragmentation, the share of socialists, and municipal revenue affect efficiency. Does their negative effect on efficiency reflect high resource use, high student achievement, or both? The issue is investigated by running simple regressions with average adjusted grades and number of teacher hours per student as dependent variables, and with party fragmentation, the share of socialists, and municipal revenue as explanatory variables. In addition, the share of students with special needs is included in both equations. The inverse number of students and the share of the population living in rural areas are included in the teacher-hours-per-student equation.

The estimation results reveal that municipal revenue contributes to both high student achievement (assessment grades) and high resource use per student. However, we know from table 5 that the effect of increased resource use dominates the effect of higher achievement, i.e., a high level of municipal revenue contributes to low educational efficiency. For the political variables the effects on resource use and performance work in the same direction. A high degree of party fragmentation and a large share of socialists contribute to both increased resource use and lower achievement. The effect of party fragmentation is significant on achievement, but not on resource use. The share of socialists is highly significant in all equations except the equation for exam results.

Table 6
The Determinants of Adjusted Grades and Teacher Hours per Student

	Adjusted assessment grades in core subjects	Adjusted assessment grades in other subjects	Adjusted exam result	Number of teacher hours per student
Share of students with special needs	0.375 (1.58)	0.027 (0.12)	0.089 (0.29)	99.664 (3.95)
Municipal revenue	0.149 (4.08)	0.152 (4.33)	0.046 (0.98)	24.287 (5.90)
Herfindahl index of (inverse) party fragmentation	0.150 (1.62)	0.151 (1.71)	0.230 (1.94)	−11.783 (1.01)
Share of socialists in the local council	−0.102 (1.90)	−0.126 (2.44)	−0.105 (1.52)	16.258 (2.66)
Inverse number of students in local council				1.948 (16.36)
The share of the population living in rural areas				8.655 (2.59)
Observations	426	426	426	426
R^2	0.07	0.08	0.02	0.66

Notes: OLS estimates with absolute *t*-values in parentheses.

7. Concluding Remarks

The purpose of this paper was to calculate the efficiency potential in the lower-secondary-school sector in Norway and to analyze the efficiency variation across municipalities. In a DEA analysis, with grades adjusted for family background as outputs and teacher hours as inputs, the national efficiency potential was calculated to be 14%. The calculated efficiency potential is fairly robust to outliers and the formulation of the educational production function. Based on a comparison of municipalities with roughly the same number of students, we find that the efficient municipalities from the DEA analysis are characterized by relatively low resource use per student, and (except for the largest municipalities) they also have relatively high student achievement.

In a second-stage analysis we ran tobit regressions in order to explain the variations in efficiency scores across municipalities. We find that a fragmented local council, a high share of socialists, and a high level of municipal revenue are associated with low efficiency. In additional regressions we investigate how party fragmentation, the share of socialists, and the level of municipal revenue affect efficiency, i.e., whether the negative effect on efficiency reflects high resource use per student, low student performance, or both. For party fragmentation and the share of socialists we find that the negative effect on efficiency reflects both higher resource use per student and lower student performance. Higher municipal revenue contributes both to high student performance and to high resource use per student, but the overall effect is to reduce efficiency.

8. Appendix

Table 7
Descriptive Statistics for Grades in the Final Year

	Mean	Coefficient of variation	Min	Max
School year 2001/02				
Norwegian	3.81	0.060	3.00	4.83
English	3.69	0.072	2.73	4.73
Mathematics	3.44	0.081	2.29	4.45
Other subjects	4.02	0.049	3.33	4.78
Written exam	3.39	0.088	2.53	4.75
School year 2002/03				
Norwegian	3.83	0.065	3.00	4.75
English	3.69	0.065	2.83	4.56
Mathematics	3.46	0.078	2.67	4.33
Other subjects	4.04	0.049	3.74	4.76
Written exam	3.39	0.087	2.25	4.33

Notes: The figures are based on data for 426 municipalities. The reported means are unweighted averages.

Table 8
Descriptive Statistics for the Variables in the Student Level Regressions

Variable	School year 2001/02				School year 2002/03			
	Mean (s.d.)	Min	Max	No. of obs.	Mean (s.d.)	Min	Max	No. of obs.
Girl	0.472 (0.499)	0	1	51,098	0.4926 (0.500)	0	1	52,928
Immigrant	0.086 (0.280)	0	1	51,098	0.0626 (0.242)	0	1	52,928

Table 8
continued

Variable	School year 2001/02 Mean (s.d.)	Min	Max	No. of obs.	School year 2002/03 Mean (s.d.)	Min	Max	No. of obs.
Adopted	0.009 (0.095)	0	1	51,098	0.0090 (0.094)	0	1	52,928
Father's highest education is upper secondary	0.572 (0.495)	0	1	51,098	0.5751 (0.494)	0	1	52,928
Father's highest education is lower tertiary	0.179 (0.383)	0	1	51,098	0.1778 (0.382)	0	1	52,928
Father's highest education is upper tertiary	0.093 (0.290)	0	1	51,098	0.0884 (0.284)	0	1	52,928
Mother's highest education is upper secondary	0.581 (0.493)	0	1	51,098	0.5804 (0.493)	0	1	52,928
Mother's highest education is lower tertiary	0.257 (0.437)	0	1	51,098	0.2562 (0.437)	0	1	52,928
Mother highest education is upper tertiary	0.033 (0.178)	0	1	51,098	0.0337 (0.180)	0	1	52,928
Mean educational level of peers' parents*	7.884 (0.944)	2.4	12	49,756	7.890 (0.952)	3.4	12	50,663
Student born in second quarter	0.261 (0.439)	0	1	51,098	0.2603 (0.439)	0	1	52,928
Student born in third quarter	0.256 (0.436)	0	1	51,098	0.2539 (0.435)	0	1	52,928
Student born in fourth quarter	0.220 (0.414)	0	1	51,098	0.2257 (0.418)	0	1	52,928
Student born earlier than its cohort	0.009 (0.095)	0	1	51,098	0.0083 (0.090)	0	1	52,928
Student born later than its cohort	0.017 (0.127)	0	1	51,098	0.0165 (0.127)	0	1	52,928
Parents living together as married	0.644 (0.479)	0	1	51,098	0.6234 (0.485)	0	1	52,928
Parents are cohabitants	0.043 (0.204)	0	1	51,098	0.0488 (0.215)	0	1	52,928
Parents separated	0.032 (0.177)	0	1	51,098	0.0340 (0.181)	0	1	52,928
Parents divorced	0.093 (0.290)	0	1	51,098	0.0928 (0.290)	0	1	52,928
Single mother	0.193 (0.395)	0	1	51,098	0.1979 (0.398)	0	1	52,928
Father's income (in 100,000 NOK)	4.205 (5.570)	0	622.4	49,079	4.536 (9.883)	0	167.0	50,632
Mother's income (in 100, 000 NOK)	2.313 (1.805)	0	123.2	50,579	2.511 (3.407)	0	39.3	52,387
Share of students receiving adapted teaching at the school	0.068 (0.032)	0.435	1	1,102	0.069 (0.036)	0	1	1,079

* The educational level of peers' parents is measured on a scale from 0 to 8, where 0 is no schooling and 8 is education on PhD level. The variable reflects the sum of the level of education for both parents.

Table 9
The Determinants of Assessment Grades and Exam Results, Individual Level

	Norwegian	English	Mathematics	Other subjects	National exam
Girl	0.636	0.471	0.141	0.444	0.297
	(89.42)	(59.08)	(18.22)	(74.64)	(32.62)
Immigrant	−0.157	−0.188	−0.262	−0.158	−0.229
	(9.81)	(10.21)	(15.50)	(11.46)	(12.27)
Adopted	−0.258	−0.311	−0.575	−0.273	−0.420
	(7.74)	(8.28)	(15.41)	(10.78)	(11.23)
Father's highest education is upper secondary	0.190 (21.84)	0.218 (22.27)	0.257 (25.26)	0.187 (25.06)	0.213 (20.29)
Father's highest education is lower tertiary	0.509 (45.98)	0.579 (45.63)	0.641 (47.09)	0.461 (48.00)	0.559 (41.05)
Father's highest education is upper tertiary	0.614 (43.06)	0.713 (42.65)	0.804 (45.64)	0.541 (45.92)	0.681 (39.82)
Mother's highest education is lower tertiary	0.254 (50.93)	0.276 (24.14)	0.318 (28.50)	0.535 (28.74)	0.613 (22.21)
Mother's highest education is lower tertiary	0.601 (27.42)	0.636 (46.00)	0.702 (51.23)	0.242 (52.03)	0.257 (44.55)
Mother highest education is upper tertiary	0.734 (38.82)	0.813 (37.45)	0.918 (40.64)	0.628 (42.32)	0.807 (36.05)
Student born in second quarter	−0.042 (5.30)	−0.029 (3.16)	−0.042 (4.35)	−0.027 (4.02)	−0.029 (3.05)
Student born in third quarter	−0.088 (11.50)	−0.068 (7.67)	−0.090 (10.02)	−0.074 (11.83)	−0.070 (8.03)
Student born in fourth quarter	−0.146 (17.82)	−0.123 (13.20)	−0.136 (13.56)	−0.118 (17.35)	−0.112 (12.02)
Student born earlier than 1986–1987	0.160 (5.83)	0.341 (10.34)	0.291 (8.41)	0.139 (6.15)	0.302 (8.69)
Student born later than 1986–1987	−0.419 (15.61)	−0.547 (18.06)	−0.496 (16.97)	−0.358 (16.78)	−0.532 (16.30)
Parents living together as married	0.257 (27.64)	0.230 (22.61)	0.383 (36.20)	0.316 (39.05)	0.246 (23.27)
Parents are cohabitants	0.144	0.138	0.229	0.179	0.146
	(9.84)	(8.51)	(13.63)	(14.97)	(8.50)
Parents separated	0.056	0.020	0.093	0.059	0.052
	(2.81)	(0.89)	(4.20)	(3.65)	(2.34)
Parents divorced	0.033	0.007	0.050	0.027	0.024
	(2.08)	(0.39)	(2.77)	(2.05)	(1.32)
Single mother	−0.026	0.027	−0.035	−0.016	−0.010
	(1.71)	(1.65)	(2.08)	(1.25)	(0.61)
Father's income	0.002	0.002	0.003	0.002	0.002
	(1.77)	(1.90)	(1.75)	(1.65)	(1.58)
Mother's income	0.006	0.008	0.009	0.008	0.006
	(2.39)	(2.84)	(2.58)	(3.01)	(2.16)
Share of students receiving adapted teaching at the school	0.044 (0.22)	−0.385 (1.79)	−0.513 (2.31)	−0.206 (1.20)	−0.371 (1.78)

Table 9
continued

	Norwegian	English	Mathematics	Other subjects	National exam
Written exam in mathematics					−0.234 (19.41)
Written exam in Norwegian					0.083 (6.16)
Mean educational level of peers' parents					0.040 (5.06)
No. of observations	98,647	97,484	98,501	99,311	94,424
R^2	0.27	0.21	0.21	0.29	0.20

Notes: OLS estimates with absolute *t*-values in parentheses. Municipal fixed effects and year-specific intercepts (not reported) are included in all equations.

Table 10
Descriptive Statistics for the Variables in the Tobit Regressions

Variable	Mean	Standard deviation	Minimum value	Maximum value
Level of education	0.167	0.049	0.079	0.422
Share of minority students	0.027	0.023	0	0.184
Share of students with special needs	0.073	0.031	0	0.176
Average school size (in 100)	1.546	1.010	0.110	4.826
Share of the population living in rural areas	0.486	0.267	0.004	0.997
Population size (in 1000)	10.55	30.18	0.35	512.09
Municipal revenue	1.039	0.214	0.880	3.180
Herfindahl index of (inverse) party fragmentation	0.266	0.087	0.140	1
Share of socialists in the local council	0.366	0.141	0	0.846
Centralized budgetary procedure	0.831	0.373	0	1
School choice	0.27	0.333	0	1

References

Banker, R. D., Charnes, A., and Cooper, W. W. (1984), Some Models for Estimating Technical Scale and Inefficiency in Data Envelopment Analysis, Management Science 30, 1078–1092.

Bessent, A., Bessent, W., Kennington, J., and Reagan, B. (1982), An Application of Mathematical Programming to Assess Productivity in the Houston Independent School Districts, Management Science 28, 1355–1367.

Bonesrønning, H., and Rattsø, J. (1994), Efficiency Variation among the Norwegian High Schools: Consequences of Equalization Policy, Economics of Education Review 13, 289–304.

Borge, L.-E. (2000), Charging for Public Services: The Case of Utilities in Norwegian Local Governments, Regional Science and Urban Economics 30, 703–718.

Borge, L.-E. (2005), Strong Politicians, Small Deficits: Evidence from Norwegian Local Governments, European Journal of Political Economy 21, 325–344.

Borge, L.-E., Falch, T., and Tovmo, P. (2005), Efficiency in Public Service Production: The Impact of Political and Budgetary Institutions, Mimeo, Department of Economics, Norwegian University of Science and Technology.

Charnes, A., Cooper, W. W., and Rhodes, E. (1978), Measuring the Efficiency of Decision Making Units, European Journal of Operational Research 2, 429–444.

Coelli, T., Prasada Rao, D. S., and Battese, G. (1998), An Introduction to Efficiency and Productivity Analysis, Kluwer Academic Publishers.

De Borger, B., and Kerstens, K. (1996), Cost Efficiency of Belgian Local Governments: A Comparative Analysis of FDH, DEA and Econometric Approaches, Regional Science and Urban Economics 26, 145–170.

Duncombe, W., Miner, J., and Ruggiero, J. (1997), Empirical Evaluation of Bureaucratic Models of Inefficiency, Public Choice 93, 1–18.

Grosskopf, S., Hayes, K. J., Taylor, L. L., and Weber, W. L. (2001), On the Determinants of School District Efficiency: Competition and Monitoring, Journal of Urban Economics 49, 453–478.

Hanushek, E. (1986), The Economics of Schooling: Production and Efficiency in Public Schools, Journal of Economic Literature 24, 1141–1177.

Hanushek, E. (2002), Publicly Provided Education, Working Paper 8799, National Bureau of Economic Research.

Hjalmarsson, L., Kumbhakar, S. C., and Heshmati, A. (1996), DEA, DFA and SFA: A Comparison, Journal of Productivity Analysis 7, 303–327.

Hoxby, C. M. (2000), Does Competition Among Public Schools Benefit Students and Taxpayers?, American Economic Review 90, 1209–1238.

Hægeland, T., Raaum, O., and Salvanes, K. G. (2004), Pupil Achievement, School Resources and Family Background, Mimeo, Ragnar Frisch Centre for Economic Research and Statistics Norway.

Kalseth, J. (2003), Political Determinants of Efficiency Variation in Municipal Service Production: An Analysis of Long-Term Care in Norway, PhD thesis, Department of Economics, Norwegian University of Science and Technology.

Kalseth, J., and Rattsø, J. (1998), Political Control of Administrative Spending: The Case of Local Governments in Norway, Economics and Politics 10, 63–83.

Kirjavainen, T., and Loikkanen, H. A. (1998), Efficiency of Finnish Senior Secondary Schools: An Application of DEA and Tobit Analysis, Economics of Education Review 17, 377–394.

Ladd, H. F., and Fiske, E. B. (2003), Does Competition Generate Better Schools? Evidence from New Zealand, Working Paper SAN01–16, Terry Sanford Institute of Public Policy, Duke University.

Simar, L., and Wilson, P. W. (1998), Sensitivity Analysis of Efficiency Scores: How to Bootstrap in Nonparametric Frontier Models, Management Science 44, 49–61.

Simar, L., and Wilson, P. W. (2000), Statistical Inference in Nonparametric Frontier Models: The State of the Art, Journal of Productivity Analysis, 12, 49–78.

Simar, L., and Wilson, P. W. (2004), Performance of the Bootstrap for DEA Estimators and the Iterating Principle, in: Cooper, W. W., Seiford, L. M., and Zhu, J. (eds.), Handbook on Data Envelopment Analysis, Kluwer Academic Publishers, Boston, 265–298.

Tovmo, P. (2006), Budgetary Procedures and Deficits in Norwegian Local Governments, Economics of Governance, forthcoming.

Worthington, A. C. (2001), An Empirical Survey of Frontier Efficiency Measurement Techniques in Education, Education Economics 9, 245–268.

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