EFFICIENCY POTENTIAL AND EFFICIENCY VARIATION IN NORWEGIAN LOWER SECONDARY SCHOOLS

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Abstract

The paper performs an efficiency analysis of the lower secondary school sector in Norway. The efficiency potential is calculated to 14 percent 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.

JEL Code: I21.

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

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1. Introduction

The educational sector has received substantial attention in the academic and political debate in recent years. International knowledge tests have provided new and easy 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 who allocate 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 best) average student performance, is no exception from this "rule". The mismatch between resource use and performance has triggered a political debate regarding resource use, curriculum and the organization of the school sector. Actions are taken to increase the number of hours in basic subjects, to provide better information on the performance of individual schools and to open up for 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 to other countries, but rather by comparing performance and resource use among Norwegian schools. Our aim is to calculate the gain that can 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), that 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]

Compared to the existing international literature we make two contributions. The first relates to the handling of family background as 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 on 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 by this approach is that the inputs in the DEA analysis can be restricted to factors under direct control of the educational institution

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

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 impact of political and budgetary institutions of the municipality, along with traditional variables like school size.

In Norway primary and lower secondary educations is mainly a municipal responsibility, and the municipalities are the units of observations in this study. The DEA analysis reveals large variations in efficiency across municipalities, and the average efficiency potential is calculated to 14 percent. 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. 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, while 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 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 percent of the students, and until the school year 2003/04 the few private schools 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 non-religious private schools that use traditional educational methods. This study is based on data for the school years 2001/02 and 2002/03 and do only include municipal schools.

Norwegian municipalities are multi-purpose 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 percent of current revenue), block grants (21 percent), earmarked grants (13 percent) and user charges (16 percent). Interest and other revenue account for the rest. Since earmarked grants and user charges are practically non-existent 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 percent 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 are decided locally, subject to national regulations and minimum standards. In the educational sector there is a national curriculum and minimum standards are determined by maximum class size and minimum number of hours per class in each subject. Moreover, until 2004 the teacher unions negotiated wage and work load (teaching hours per week) with 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 across schools is too 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. Settlement pattern, the number of students in the municipality and 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 (DEA)

In this section we introduce the concept of technical efficiency and use a simple case to illustrate how relative efficiency is calculated in the DEA procedure. We pay particular attention to the potential problems and challenges that arise when this method is applied to the educational sector.

Data envelopment analysis was first introduced by Charnes, Copper and Rhodes (1978) in order to calculate relative technical efficiency in the case of multiple inputs or outputs in the production process of non-profit 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 in this paper is to minimize the level of inputs for a given amount of outputs.[2] This is done by simultaneously solving a linear programming problem for each unit (schools or municipalities in our case). Generally municipalities (or schools) will value their inputs and outputs differently and thus call for different sets of weights in the conventional measure of relative efficiency.[3] 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. The method requires no a priori specification of the functional form of the educational production function.

We will now consider a simplified educational sector where the schools use only one input (teachers) to produce a single output (student achievement) to illustrate how this best practice reference frontier and the efficiency measures are determined in the DEA procedure. The simplification allows us to describe the production process in a simple two-dimensional diagram as in figure 1 below. The points A, B, C and K represents locations of different municipalities in the teacher (input) and student achievement (output) space.

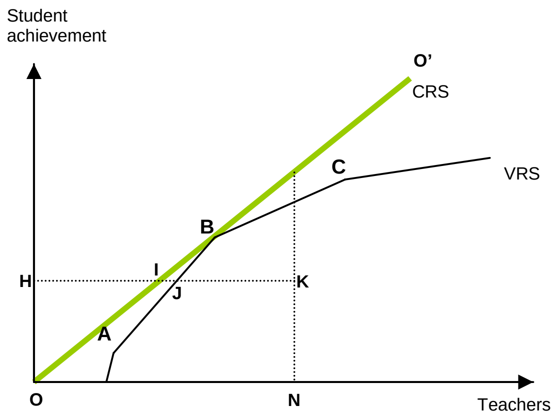
The DEA model originally proposed by Charnes, Coper and Rhodes (1978) was input oriented and allowed only for constant returns to scale. This approach has since then been widely developed, see e.g. Banker, Charnes and Cooper (1984) where a variable return to scale specification was first proposed. We 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.[4] Observation B lies on the reference

[2] 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.
[3] Conventionally relative efficiency is calculated as weighted outputs to weighted inputs with a common set of weights.
[4] When drawing a line from the origin trough the sample observations in figure 1, the line passing trough observation B has the greatest slope. Observation B is the most productive of the sample observations. All the other observations lie below this line.

frontier and is assumed to be fully efficient, while the observations that lie under the line OO' are inefficient, e.g. observations A, C and K. Inefficiency implies that the observed units could have produced the same level of outputs by using less input given that they adapted the "best practice" technology defined by the reference frontier. The efficiency of a municipality depends on the distance to the efficiency 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) the ratio is equal to one.

Figure 1

The best practice reference frontier under constant and variable return to scale



If we consider variable returns to scale the reference frontier is represented by the piecewise linear curve passing trough the observations A, B and C in figure 1. In this case only observation K is situated below the efficiency frontier and is defined as ineffective. Given the output of municipality K the efficient amount of inputs is defined by point J in figure 1, and the relative efficiency (or efficiency score) is thus given by the ratio HJ/HK. It follows from figure 1 that the input- and output-oriented efficiency measures will be identical in the case of constant returns to scale, but will differ in the case of variable returns to scale.

One property by the DEA method is that the number of efficient units and the calculated efficiency potential depends 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 the efficiency potential.

When the DEA method is applied to the education 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 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 dataset 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 by this approach is that the inputs in the DEA analysis can be restricted to factors under direct control of the educational institution and that 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 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 do 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 levels of 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 levels of output and/or high input will only have a minor impact since they only affect 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 helps to reduce the problem with 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. We follow this tradition by constructing output measures based on grades in the core subjects Norwegian, mathematics and English, as well as the average grade in other subjects, at the end of lower secondary school. All students get assessment grades based on class work during the three years (8th to 10th grade) of lower secondary education. In the final year there are written national exams in the core subjects, but each student does not take more than one exam. Even at the municipal level there are many cases where all three core subjects are not covered by national exams.

The point of departure is the assessment grades in the 10th grade for the school year 2001/02 and 2002/03. Some descriptive statistics for the mean assessment grades are given in the appendix table A1. 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, and 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.

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 52,713 students for the academic year 2001/2002 and for 53,593 students for the academic year 2002/2003. 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

$$y_{ijt} = \beta x_{ijt} + \gamma_t + \alpha_j + u_{ijt} \qquad (1)$$

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 municipal fixed effects and u_{ijt} 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, and for the average grade of the remaining subjects. The *x* vector contains variables that are typically used in analyses of student achievement.[5] The *x*-vector includes a number of individual dummy variables on the student's gender, quarter of birth (given that they graduated in the year they turn 16), graduation earlier or later than expected, and whether they are immigrants or adopted. Family background is captured by parents' education and

[5] See Hægeland, Raaum and Salvanes (2004) for a more detailed examination of the data.

income (separate for the mother and the father) and dummy variables reflecting whether the parents are married to each other, cohabitants, separated, divorced or neither of these cases. We do not have information on whether individual students receive adapted teaching due to learning disabilities, only 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*. The appendix table A2 reports descriptive statistics for the *x* variables, while the regression results are reported in table A3.

The estimation results reported in table A3 mainly serves to control students achievement for the available variables capturing family background, and the estimated coefficients do to a great extent confirm the findings from other analyses on the impact 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. Briefly 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 as married or cohabitants) receive better grades than students living with 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 high share of students with special needs have relatively lower achievement level.

Table 1
Descriptive statistics adjusted assessment grades, teacher hours per student and the fraction of certified teachers

	Mean	Coefficient of variation	Min	Max
Adjusted assessment grades				
Norwegian	3.55	0.05	2.94	4.34
English	3.53	0.05	3.04	4.19
Mathematics	3.54	0.05	2.99	4.42
Other subjects	3.54	0.04	3.14	4.16
Teacher hours per student	96.2	0.28	61.3	226.2
The fraction of certified teachers	0.95	0.06	0.69	1.00

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

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

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 62 hours per student to a high of 279 hours per student. On average only 5 percent of the teachers are non-certified, but in individual municipalities up to about 30 percent of the teaching staff are non-certified.

Table 2 displays the correlations between grades and teachers hours per pupil and the fraction of certified teachers. It appears that the four output measures are positively correlated. The correlations between the adjusted assessment grades in the different subjects are in the range 0.4-0.7. Teacher hours per student are positively correlated with adjusted assessment grades, whereas the fraction of certified teachers is only weakly correlated with the four outputs. The positive correlation between adjusted grades and teacher hours per pupil 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.

Table 2
Correlation matrix for adjusted grades, teacher hours per pupil and the fraction of qualified teachers

	Norwegian	English	Mathematics	Other subjects	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	0.692	0.622	0.607	1.000		
Teacher hours per student	0.311	0.319	0.287	0.391	1.000	
Share of certified teachers	-0.079	-0.089	0.006	-0.092	-0.241	1.000

[6] 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.

In the DEA analysis we use two specifications of the educational production. 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 number of teacher hours given by certified and non-certified teachers respectively. The two models differ in the specification of outputs. In the first model (A) the adjusted grades in the core subjects Norwegian, English and Mathematics are used as outputs. The second model (B) extends model A by including grades in other subjects than the three core subjects. The outputs are specified as the adjusted grades multiplied by the number of students.[7] In both 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 426 (out of 434) municipalities.

5. Educational efficiency: The results of the DEA analysis

Descriptive statistics for the efficiency scores from model A and B are reported in table 3. In model A the mean efficiency score is 0.78 when all municipalities are given equal weight, i.e. the average municipality could reduce inputs by 22 percent without reducing measured output. The results are similar to the US 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 states school districts, whereas Grosskopf et al (analyzing public schools in Texas) find that inputs could be reduced by roughly 20 percent without reducing output. Kirjavainen and Loikkanen (1998) find average efficiency of 0.82-0.84 in an analysis of senior secondary schools in Finland.

However, 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 percent. The calculated efficiency potential reflects

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

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 percent of the municipalities come out with an efficiency score below 0.71, and other 25 percent have efficiency score above 0.87.

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

Table 3
Descriptive statistics for the calculated efficiency scores

	# 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

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 effective unit is left out, the mean efficiency score of the remaining units will generally increase.[8] The evaluation is by how much mean efficiency increases. The results from these 19 additional DEA analyses are reported in the appendix table A4. It turns out that the benchmark efficiency scores are very robust to outliers as mean efficiency increases by one percentage point or less in 17 of the 19 cases. In the last cases the increase is slightly above one percentage points. The rank correlation with the efficiency scores from model A and the various jack-knife models varies between 0.97 and 1.

Table 4 provides more information about grades and teachers hours per student in the efficient municipalities (from model A), and they are also compared with all municipalities with

[8] Mean efficiency fro the remaining units is unaffected if the unit that is left out is not a reference for any ineffective unit.

roughly the same number of students. The efficient municipalities are divided in 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 can not be compared with inefficient municipalities with a similar number of students.

Table 5
Describing the efficient municipalities from 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

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 percent above the mean of all other municipalities in the group, and the number of teacher hours per student is 22 percent below. Also in the group with 190-400 students the best performing municipalities (EM5-EM8) are characterized by high grades and low resource use. Grades are on average 1-5 percent higher than the mean of the group and teacher hours per student 22 percent lower. In the largest group (700-1400 students) the efficient municipalities (EM9-EM12) do not have better 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 terms of high student performance. In the Norwegian case efficient municipalities are rather characterized by low resource use, but where the low resource is not associated with low student performance.

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. Among the few studies attempting to explain variation in educational efficiency are Duncombe, Miner and Ruggiero (1997) and Grosskopf et al (2001) that focuses 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 focuses 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 impact 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 is shown to reduce administrative spending (Kalseth and Rattsø, 1998) and to increase efficiency (Kalseth, 2003, and 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

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

where SH_p is the share of representatives from party *p*. The index takes the maximum value of 1 when a single party holds all the seats in the local council, while the minimum value of 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 impact on efficiency.

In Norway the socialist camp is dominated by the Labor Party, while the non-socialist 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. There is then an argument to include the share of socialists in the analysis to get an unbiased estimate of the Herfindahl-index. More substantial arguments are that earlier studies document that a high share of socialists are associated with high administrative spending (Kalseth and Rattsø, 1998), low efficiency in the care for the elderly sector (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 the 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. A centralized budgetary procedure is characterized by the head of the administration (administrative centralized procedure) or the executive board (political centralized procedure) presenting an overall budget proposal for each sector, and the sectors only work out specific details within their sector. A decentralized or fragmented budgetary procedure is on the other hand characterized by each sector working out heir 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 (2005) finds that a centralized budgetary contributes to lower budget deficits, while Borge, Falch and Tovmo (2005) find no significant effect on overall efficiency.

The earlier studies (Kalseth and Rattsø, 1998, Kalseth, 2003, and 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" by enjoying more budgetary slack. As indicator of municipal revenue we use local taxes and block grants per capita deflated by an index that captures varying cost conditions across local governments. This revenue indicator is widely accepted as the most reliable indicator of differences in economic conditions across local governments.

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 in the three first columns use the efficiency scores from model A as dependent variable and in the final column the efficiency scores from model B.

Table 5
The determinants of educational efficiency

	I	II	III	IV
The level of education in the municipality	-0.053 (0.40)			
The share of minority students	-0.221 (0.93)			
The share of students with special needs	-0.896 (5.18)	-0.799 (3.76)	-0.780 (4.37)	-0.788 (4.41)
Average school size (in 100)	0.081 (4.23)	0.114 (4.49)		
School size squared	-0.006 (1.30)	-0.012 (2.07)		
Municipal revenue		-0.033 (0.99)	-0.124 (4.54)	-0.126 (4.60)
Herfindahl-index of (the inverse) of party fragmentation		0.349 (3.70)	0.201 (2.76)	0.199 (2.74)
The share of socialists in the local council		-0.126 (2.51)	-0.123 (2.93)	-0.125 (2.98)
Population size (in 1000)			0.002 (3.91)	0.002 (3.90)
The share of the population living in rural areas			-0.078 (3.05)	-0.080 (3.13)
Centralized budgetary procedure		-0.018 (1.10)		
Efficiency scores	Model A	Model A	Model A	Model B
Log likelihood	302.2	219.3	293.1	290.7
Observations	426	306	426	426

Note: TOBIT-estimates with absolute t-values in parentheses.

The first regression (I) disregards the possible impact 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, the share of students with special needs and the share of minority students and the level of education in the municipality. In addition we follow earlier studies of educational efficiency by including average school size.

The level of education and the share of minority students come out insignificant, which indicate that our approach of controlling for family background and student characteristics works well.[9] On the other hand, the share of student 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 the 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 impact of school size does not reflect economies of scale since variable returns to scale is allowed for in the underlying DEA analysis. It rather reflects that the variation in efficiency across municipalities is related to average school size, and more precisely that the variation is larger among the local governments with small schools.

In the second column we include municipal revenue as well as political and budgetary variables. In line with the earlier studies we find a negative and significant relationship between efficiency and the share of socialist and the degree of fragmentation in the local council, whereas the budgetary procedure does not seem to have any significant impact on efficiency.

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 the impact of revenue is captured by school size in regressions I-II. The suspicion is confirmed by regression III where we exclude the school size variables and rather include three background variables explaining school structure. These variables are municipal revenues, population size and settlement pattern. The settlement pattern is captured by the fraction of the population living in rural

[9] 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.

areas. In this case municipal revenue comes out negative and significant in line with the earlier Norwegian studies. Population size and settlement patterns also come out as significant with the expected sign, i.e. small and sparsely populated communities tend to have low efficiency. The sign and significance of the political variables are robust to this modification of the model specification, but the quantitative effect of the Herfindahl-index is somewhat reduced.

In the final column (IV) we use the efficiency scores from model B instead of the efficiency scores from model A as dependent variable. I turns out that the estimated coefficients are more or less identical to those of column III. In fact, this is no surprise given the high correlation between the efficiency scores from the two models.

Table 6
The determinants of adjusted grades and teacher hours per student

	Average adjusted grades in core subjects	Average adjusted grades in other subjects	Number of teacher hours per student
The share of students with special needs	0.376	-0.032	99.664
	(1.58)	(0.14)	(3.95)
Municipal revenue	0.149	0.157	24.287
	(4.08)	(4.43)	(5.90)
The share of socialists in the local council	-0.102	-0.132	16.258
	(1.90)	(2.53)	(2.66)
Herfindahl-index of (the inverse) of party fragmentation	0.150	0.180	-11.783
	(1.62)	(2.01)	(1.01)
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
R-squared	0.07	0.08	0.66

Note: OLS-estimates with absolute t-values in parentheses.

In table 6 we investigate how party fragmentation, the share of socialists and municipal revenue affect efficiency. Does the negative impact on efficiency reflect high resource use, high student performance, or both? The issue is investigated by running simple regressions with average adjusted assessment grades and 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 results indicate that municipal revenue affects efficiency in a different way than the political variables. A high level of municipal revenue contributes to both high student performance and high resource use per student. However, we know from Table 5 that the impact of increased resource use dominates the impact of higher performance, i.e. a high level of municipal revenue contributes to low educational efficiency. For the political variables the impacts on resource use and performance work in the same direction. A high degree of party fragmentation and a high degree of socialists contribute to both increased resource use and to lower performance. The share of socialists is highly significant in all three equations, whereas the Herfindahl index is significant in the equation for adjusted grade in other subjects and marginally significant only in the equation for grades in core subjects.

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 assessment grades adjusted for family background as outputs and teacher hours as inputs, the national efficiency potential was calculated to 14 percent. The calculated efficiency potential is fairly robust to outliers. 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 better student performance.

In a second a 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 affects efficiency, i.e. does the negative impact on efficiency reflect high resource use per student, low student performance, or both? For party fragmentation and the share of socialist we find that the negative impact 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 tables

Table A1
Descriptive statistics assessment grades

	Mean	Coefficient of variation	Min	Max
School year 2001/02				
Norwegian	3.81	0.06	3.00	4.83
English	3.69	0.07	2.73	4.73
Mathematics	3.44	0.08	2.29	4.45
Other subjects	4.02	0.05	3.33	4.78
School year 2002/03				
Norwegian	3.83	0.06	3.00	4.75
English	3.69	0.06	2.83	4.56
Mathematics	3.46	0.07	2.67	4.33
Other subjects	4.04	0.05	3.74	4.76

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

Table A2
Descriptive statistics for the variables in the student level regressions

	2001/2002				2002/2003			
Variable	Mean (st.dev)	Min	Max	# of obs.	Mean (st.dev)	Min	Max	# 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
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
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	622.3 9	49,079	4.536 (9.883)	0	167.00	50,632
Mother's income (in 100 000NOK)	2.313 (1.805)	0	123.2 2	50,579	2.511 (3.407)	0	39.30	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

Table A3

The determinants of individual assessment grades

	English	Norwegian	Mathematics	Other subjects
Year effect: dummy equals one when year is 2002/2003	0.011	0.027	0.022	0.026
	(1.70)	(4.97)	(3.34)	(5.78)
Girl	0.471	0.636	0.141	0.445
	(75.73)	(116.74)	(21.78)	(100.30)
Immigrant	-0.188	-0.156	-0.262	-0.178
	(13.38)	(12.76)	(18.04)	(16.83)
Adopted	-0.311	-0.258	-0.575	-0.281
	(9.57)	(9.08)	(16.94)	(12.34)
Father's highest education is upper secondary	0.218	0.189	0.257	0.190
	(22.73)	(22.61)	(25.86)	(27.23)
Father's highest education is lower tertiary	0.578	0.509	0.641	0.464
	(48.72)	(48.95)	(51.92)	(53.99)
Father's highest education is upper tertiary	0.713	0.613	0.804	0.543
	(48.22)	(47.29)	(52.25)	(50.98)
Mother's highest education is upper secondary	0.276	0.254	0.318	0.244
	(26.89)	(28.35)	(29.84)	(32.75)
Mother's highest education is lower tertiary	0.637	0.601	0.702	0.537
	(53.41)	(57.66)	(56.71)	(62.37)
Mother highest education is upper tertiary	0.814	0.735	0.918	0.629
	(38.67)	(39.71)	(41.84)	(41.64)
Student born in second quarter	-0.029	-0.042	-0.042	-0.026
	(3.33)	(5.47)	(4.54)	(4.14)
Student born in third quarter	-0.068	-0.088	-0.090	-0.075
	(7.69)	(11.36)	(9.81)	(11.89)
Student born in fourth quarter	-0.123	-0.146	-0.136	-0.117
	(13.48	(18.22)	(14.33)	(17.99)
Student born earlier than 1986/1987	0.341	0.160	0.291	0.125
	(10.08)	(5.36)	(8.24)	(5.11)
Student born later than 1986/1987	-0.547	-0.418	-0.496	-0.384
	(19.10)	(17.25)	(17.19)	(19.26)
Parents living together as married	0.230	0.257	0.383	0.316
	(23.17)	(29.52)	(37.07)	(44.76)
Parents are cohabitants	0.138	0.144	0.229	0.180
	(8.70)	(10.35)	(13.88)	(15.95)
Parents separated	0.020	0.056	0.093	0.055
	(0.92)	(2.95)	(4.15)	(3.55)
Parents divorced	0.007	0.033	0.050	0.027
	(0.41)	(2.23)	(2.88)	(2.25)
Single mother	0.027	-0.026	-0.035	-0.015
	(1.66)	(1.82)	(2.09)	(1.35)
Father's income (in 100.000 NOK)	0.002	0.002	0.003	0.002
	(5.17)	(5.22)	(6.71)	(7.06)
Mother's income (in 100.000 NOK)	0.008	0.006	0.009	0.008
	(6.88)	(5.74)	(7.04)	(9.29)
Share of students receiving adapted teaching at the school	-0.386	0.043	-0.515	-0.203
	(2.93)	(0.37)	(3.76)	(2.16)
Jurisdiction fixed effects	yes	yes	yes	yes
# obs.	97,487	98,652	98,504	98,007
R-squared	0.21	0.27	0.21	0.28

Note: OLS-estimates with absolute t-values in parentheses.

Table A4

Jackknifing results

	# obs.	Mean	Standard deviation	Minimum value	Maximum value
1	425	0.794	0.121	0.428	1
2	425	0.784	0.121	0.424	1
3	425	0.784	0.121	0.424	1
4	425	0.783	0.121	0.424	1
5	425	0.789	0.124	0.424	1
6	425	0.784	0.121	0.424	1
7	425	0.787	0.122	0.424	1
8	425	0.784	0.121	0.424	1
9	425	0.784	0.121	0.424	1
10	425	0.784	0.121	0.425	1
11	425	0.784	0.121	0.424	1
12	425	0.795	0.119	0.424	1
13	425	0.784	0.121	0.424	1
14	425	0.784	0.121	0.424	1
15	425	0.784	0.121	0.424	1
16	425	0.784	0.121	0.424	1
17	425	0.784	0.122	0.424	1
18	425	0.785	0.121	0.427	1
19	425	0.784	0.121	0.424	1

Table A5

Descriptive statistics for the variables in the TOBIT regressions

Variable	Mean	Standard deviation	Minimum value	Maximum value
The level of education in the municipality	0.167	0.049	0.079	0.422
The share of minority students	0.027	0.023	0	0.184
The 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
Municipal revenue	1.039	0.214	0.880	3.180
Herfindahl-index of (the inverse) of party fragmentation	0.266	0.087	0.140	1
The share of socialists in the local council	0.366	0.141	0	0.846
The share of the population living in rural areas	0.486	0.267	0.004	0.997
The share of the population living in rural areas	10.546	30.180	0.348	512.093
Centralized budgetary procedure	0.831	0.373	0	1

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