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# Municipalities as Educational Producers - An Efficiency Approach

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## Abstract

This paper studies efficiency in the provision of public education by local authorities using Data Envelopment Analysis (DEA). Viewing education as a multilevel production process the models control for differences at other levels. Most important is the students' socioeconomic background and a number of alternative ways of modelling this are proposed. Mean efficiency is estimated to between 0.87 and 0.96. To explain the efficiency we use the estimated scores as dependent variable in a Tobit regression. The primary findings are that municipalities with a socialistic majority in the city council are less efficient, that the share of teachers having a permanent tenure increases efficiency significantly which emphasize the importance of employment contracts and, contrary to our expectations, that municipalities with many pedagogically skilled teachers are less efficient. We find no evidence of efficiency increases due to competition from private schools.

## 1 Introduction

The importance of education is seldom questioned and the provision by public and private schools is subject to both public and academic discussion. Considering the large amount

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of resources spent on education it is not surprising that the issue of an efficient use of resources is frequently highlighted. Education is often accused for being inefficient, but who is actually not using the resources efficiently? Although the national government has an educational policy a local authority or private interest is often responsible for the provision, while the actual teaching is handled by individual schools. This study focuses on the role of the local government in the Swedish school system. The purpose is to estimate efficiency in the provision of public education by the local government in a first stage and in a second stage find explanations for efficiency differences. The efficiency estimation is based on theories of education as a multilevel production process. When explaining the efficiency distribution we must consider that the local government is a political institution and education is financed primarily through local taxes. For the explanation we use both variables from the educational production process and variables based on e.g. public choice theory and principal-agent models. We use data for secondary schools from 287 (out of 289) Swedish municipalities in 2000.

Viewing education as a multilevel production we have to isolate the inefficiency due to managerial decisions at the municipal level. Inefficiency might also be caused by e.g. bad school management or resource demanding students. Since focus is on municipal managerial inefficiency the models take inefficiency in the other levels of production into account. In the literature on education consensus is reached on the great importance of the students' socioeconomic status when trying to predict educational outcomes (See e.g. Hanushek (1986), Chubb & Moe (1990) and for Swedish conditions Skolverket (1999)). By including socioeconomic variables in the efficiency models we can control for inefficiency due to differences in the production environment.

To estimate efficiency we use Data Envelopment Analysis (DEA). The method can handle both multiple inputs and multiple outputs in the same model. This is important when trying to measure school output. Not only that the most important output 'knowledge' is hard to quantify in a single measure, schools also have many other goals to reach at the same time. We take into account student grades, students not reaching minimum goals in a subject and the number of students continuing for higher education. As inputs under managerial control we use teachers, material and school premises. The efficiency models are built around the most important 'input' in the production process; the students. In the literature on education teacher/pupil ratios and corresponding outputs are used in most models. A number of studies have used this approach in DEA (e.g. Bessent, Bessent., Kennington. & Reagan (1982), Thanassoulis & Dunstan (1994), Smith & Mayston (1987) and Bradley, Johnes & Millington (2001)) where the most common

way of including the socioeconomic variables is the share of the students defined into different socioeconomic groups. In the DEA literature the standard approach is using total quantities of inputs and outputs for the production units. The approach using shares of students in different groups is not directly applicable on these models. In this paper ways of modelling socioeconomic inputs in DEA models using quantities are proposed and compared to models using teacher/pupil ratios. For explaining the efficiency distribution in a second stage we use the estimated efficiency as dependent variable in a Tobit model.

Other studies estimating efficiency in public education are e.g. *Färe, Grosskopf & Weber (1989)*, *McCarty & Yaisawarng (1993)*, *Olesen & Petersen (1995)*, *Grosskopf, Hayes, Taylor & Weber (1997)* and *Grosskopf, Hayes, Taylor & Weber (1999)*. Three studies, *Heshmati & Kumbhakar (1997)*, *Färe, Grosskopf, Forsund, Hayes & Heshmati (1997)* and *Ljunggren (1999)*, estimate efficiency for education in Sweden. *Heshmati & Kumbhakar (1997)* is the only study presenting mean efficiency which they estimate to approximately 0.90 using a stochastic approach. Papers having similar objectives as this one, continuing the analysis to explain why some schools are more efficient than others, are e.g. *Kirjavainen & Loikkanen (1998)*, *Duncombe, Miner & Ruggiero (1997)*, *Grosskopf, Hayes, Taylor & Weber (2001)*, *Bradley et al. (2001)* and *Lovell, Walters & Wood (1994)*. In the studies a number of variables both internal to the schools and in the political context are identified to affect efficiency.

The estimated mean efficiency for Swedish municipalities is 0.87 - 0.89 for models not including the production environment and 0.90 - 0.96 for models including the production environment. Thus, if efficiency is estimated without consideration to the production environment part of the inefficiency will be due to features that is not under managerial control. The primary focus of the paper is to find explanations why some municipalities are more efficient than others. Competition is by tradition an important feature in forcing production units to be efficient but we find no evidence that competition from private schools increases efficiency. In Public Choice theory focus is set on voters and local politics and we find that municipalities with socialistic majority in the city council are less efficient. This can be interpreted as the voters' tolerance for inefficiency in public provision of education is reflected in their political preferences. Other voter characteristics do not influence efficiency. As the main input under managerial control the teachers are important in education. We find evidence that labour contracts affect efficiency. Municipalities which offer their teachers a permanent tenure to a higher extent are more efficient. On the contrary, municipalities employing teachers with formal pedagogical skills are less efficient, which was not expected a priori. Possible explanations are that the

pedagogical training affects the way grades are set or that skilled teachers tend to choose inefficient municipalities if these are considered to provide better working conditions.

The paper begins with a theoretical framework followed by a discussion of efficiency models in section 3. We discuss data and the specific problems of education before choosing and estimating the efficiency models in section 4. To analyze the efficiency we need a theoretical framework and a model for finding variables explaining the efficiency scores obtained. This and the results are presented in section 5. Section 6 concludes the study.

## 2 Theoretical Framework

The production of education is a process involving decisions at a number of levels in society from the national education policies down to the individual students and their efforts in the school work. Focus in the literature of educational production is often concentrated to school inputs, in particular the teaching resource, and the students' socioeconomic status. This view is used by e.g. Hanushek (1979) who explain student achievement with four general factors: family background, peer influences, school inputs and the student's own ability. To take the analysis further school organization and institutional framework have been included in the production models (see e.g. Chubb & Moe (1990)). These features are found outside the individual schools. A theoretical framework intending to capture the entire production will involve a number of actors at different levels influencing the final result, students' knowledge. We describe the production as

$$E_i^t = f(G_i^t, LG_i^t, S_i^t, I_i^t)$$

where  $E_i^t$  is the total achieved knowledge for student  $i$  at time period  $t$ ,  $G_i^t$  is the cumulative influence from the central government on student  $i$  until time period  $t$ ,  $LG_i^t$  is the cumulative influence from the local government on student  $i$  until time period  $t$ ,  $S_i^t$  is the cumulative influence from school inputs on student  $i$  until time period  $t$  and  $I_i^t$  is the cumulative influence from the individual student's efforts and family background.

The production function above represents the maximum possible education achievable from the amount of resources spent at the different levels in the production process. This paper is concerned with the deviation from the maximum possible production. If a student does not achieve the maximum possible knowledge given the observed inputs to her education there is inefficiency somewhere in the process. The inefficiency can

originate from any of the decision making levels in the production process. Actors not primarily interested in the output might use resources to achieve other goals. Niskanen (1971) introduced the utility maximizing bureaucrat causing inefficiency by having other objectives than profit maximization. In the original model the only objective is budget maximization. Migué & Bélanger (1974) and Niskanen (1975) develop the idea of the bureaucrat not producing at minimum cost, but instead using resources to increase his own utility. A number of objectives which might increase utility for the bureaucrat, but which are not necessarily compatible with profit maximization, have been suggested: Size of the organization, salary, power etc.

Of course bureaucrats cannot increase utility without constraints. Production of education is financed by a sponsor who is interested in maximizing the educational outcomes given the taxes payed to provide public education. Viewing voters as principals and the school organization as agent in a principal-agent framework it is important with e.g. wage contracts and possibilities for monitoring to make the school organization efficient. Although monitoring increases efficiency it is also costly to the sponsor. The higher cost for the sponsor the more inefficiency he is willing to accept. The costs and benefits of monitoring is not equal for all sponsors, but could rather be seen as depending on socioeconomic status and political preferences. Some school organizations might be better suited for efficient production both through access to monitoring and through the incentives of the employees etc. In economic theory it is possible to find a number of other directions from which to approach the question of bureaucratic inefficiency. Competition is often claimed to improve efficiency and in Public Choice theory the role of politicians and voters is highlighted. We assume efficiency to be a function of school organization and of municipal characteristics including sponsor characteristics, competition etc

$$eff_t = f(v, z), l = G, LG, S, I$$

where  $v$  represent the municipal characteristics and  $z$  represents school organization.

When estimating efficiency in a production process including different levels of production, inefficiency at the other levels will be included in the estimated inefficiency for the studied level if not taken into account. A unit facing inefficient behaviour from other levels in the production process might thus be as efficient as possible but still be defined as inefficient if these production restrictions are not observed. We do in general not have information on the part of the inefficiency that is due to inefficiency at the other levels, but we can use proxies to control for differences in the production environment between units. We do e.g. know that students with certain backgrounds do get more encourage

from their family to do homework etc and thus are more "efficient" in using the teaching resource for achieving academic skills. This is often referred to as a family input that is outside the control of the educational system. Including variables representing the environment in the efficiency analysis makes it possible to estimate inefficiency that is only due to managerial decisions at the studied level.

This paper is concerned with efficiency at the local government level in Sweden. Focus of the paper is on local voter characteristics (the sponsors), differences in local school policies and competition. Efficiency at the school level is studied for Swedish conditions by Waldo (2001).

### 3 Data Envelopment Analysis (DEA)

Before dealing with the specific problems of measuring efficiency in education we will give a more general explanation below of what we mean by efficiency in this context and how we have chosen to measure it. The problem for the municipalities is to produce as much education as possible with a minimum of resources. Technical efficiency measures if a production unit actually produces its output with the minimum inputs needed. The idea is best shown in a simple figure, see figure 1.

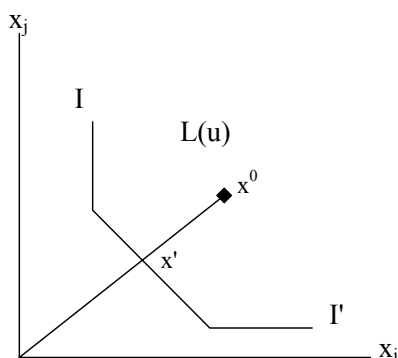


Figure 1: Technical Efficiency

Suppose that we have a sample of firms representing an industry. Each of the firms in figure 1 produces the same amount of output,  $u$ , but with different quantities of the two inputs labor ( $x_i$ ) and capital ( $x_j$ ). A production  $(x_i, x_j, u)$  is feasible if the inputs belong to the input set  $L(u)$  where  $L(u)$  represents all input combinations that can produce  $u$ .

The isoquant I-I' in figure 1 represents production of a certain amount of output using

different input mixes, where no observed firm or linear combination of observed firms are using less of both inputs. We call this the *production frontier*. A production unit lying on the isoquant I-I' is defined as technically efficient. Production unit  $x'$  is efficient, producing with minimal possible inputs. Production unit  $x^0$  uses both more labor and capital to produce  $u$ . Technical efficiency can be viewed as the ratio of  $Ox'/Ox^0$ . The closer  $x^0$  is to  $x'$  the larger will the ratio be. However the ratio can never be larger than one, which represents a technically efficient unit. We will formalize the concept of efficiency before dealing with the more delicate matter of how to apply the model on education. More detailed discussions on efficiency measurement than presented below can be found in e.g. *Färe, Grosskopf & Lovell (1994)* and *Färe (1988)*.

The example above using two inputs and one output is easy to visualize. The concept of technical efficiency can be generalized to  $K$  production units,  $M$  outputs and  $N$  inputs. We let the input set  $L(u)$  represent the possible converting of the inputs  $x = (x_1, x_2, \dots, x_N) \in \mathfrak{R}_+^N$  to outputs  $u = (u_1, u_2, \dots, u_M) \in \mathfrak{R}_+^M$  or put in another way  $L(u) = \{x: x \text{ can produce } u\}$ . To construct the production frontier we use a linear programming technique, building a piecewise linear production technology. This technology is then used as the reference against which we compute efficiency scores. This technique has two advantages: It is non parametric, so we do not need to impose any parametric form for the frontier and we can model a technology with both multiple inputs and multiple outputs. The disadvantage is that the model is not stochastic and thus sensitive for errors in the data. When estimating the efficiency scores we are interested in how much we can reduce inputs and still produce  $u$ , i.e. in finding the smallest possible  $\lambda$  (where  $0 < \lambda < 1$ ) with which we can multiply the inputs and still remain inside  $L(u)$ .  $\lambda$  is a radial contraction, that is we reduce all our inputs with the same proportion, and  $\lambda$  is thus our estimate of efficiency.  $\lambda$  is estimated for every unit separately which gives us a value of the efficiency for each unit. This is referred to as the *Input-Saving Measure of Technical Efficiency* ( $F_i$ ). Formally we define it as

$$F_i(u, x) = \min\{\lambda : \lambda x \in L(u)\}$$

which is calculated for unit  $l$  as

$$\begin{aligned} F_i(u^l, x^l | V, S) &= \min_{z, \lambda} \lambda \\ \text{s.t. } \sum_{k=1}^K z^k u_m^k &\geq u_m^l, m = 1, \dots, M \end{aligned}$$



$$\sum_{k=1}^K z^k x_n^k \leq \lambda x_n^l, n = 1, \dots, N$$

$$\sum_{k=1}^K z^k = 1, z^k \geq 0, k = 1, \dots, K$$

The  $V$  in  $F_i(u, x|V, S)$  represents *variable returns to scale* (VRS). This is the most flexible way of modelling the production technology. If a production unit produces  $y$  output using  $x$  input, we do in the VRS technology not believe that it is necessarily possible to produce  $2u$  output using  $2x$  input or  $0.5u$  of the output with  $0.5x$  of the input. If we believe in the possibility to scale the production of a unit up or down proportionally we have a *constant returns to scale* (CRS) technology.  $z = (z^1, z^2, \dots, z^K)$  is a vector of intensity variables for each of the  $K$  units that are being evaluated. The intensity vector makes it possible to reduce the activity of a production unit and by combining different units to construct a feasible production on the frontier that is actually not observed. The constraint that the  $z$ -variables sum to one gives us the VRS frontier. The  $S$  represents *strong disposability of inputs*. This means that an increase of an input does not decrease output. This is usually the case, but for example farmers putting too much fertilizer on their land can actually decrease output. In schools we expect more teachers to be able to educate more students and also to increase their results, or at least not decrease them.

We now have a measure of efficiency showing how much a production unit should be able to decrease all inputs proportionally still producing the same output. This, of course, is under the assumption that all units have the same production environment. A unit producing under bad environmental conditions is not assumed to produce as much output as a unit producing under more fortunate conditions. The environmental variables are very important when studying schools. Some students will be better at converting the schools teaching efforts into knowledge. In an efficiency model the differences in the students' background can be viewed as differences in inputs. E.g. a well motivated student is in this sense 'more' input than a less motivated student because a school is assumed to be able to produce more output the more motivated a student is in the same way as a school is assumed to be able to produce more with more of any input. There is, however, a difference in that it is not possible to decrease the characteristics of the student with some  $\lambda$  as it is with the other inputs. The environmental variables are fixed or *nondiscretionary*. In the model we incorporate them as inputs, but with no possibility of reduction with  $\lambda$ . We call the environmental variables  $a$

$$\sum_{k=1}^K z_k a_{kj} \leq a_j, j = 1, \dots, J$$

The full model is now for the  $l$ :th unit

$$\begin{aligned}
F_i(u^l, x^l, a^l | V, S) &= \min_{z, \lambda} \lambda \\
s.t. \quad \sum_{k=1}^K z^k u_m^k &\geq u_m^l, m = 1, \dots, M \\
\sum_{k=1}^K z^k x_n^k &\leq \lambda x_n^l, n = 1, \dots, N \\
\sum_{k=1}^K z^k a_j^k &\leq a_j^l, j = 1, \dots, J \\
\sum_{k=1}^K z^k &= 1, z^k \geq 0, k = 1, \dots, K
\end{aligned}$$

It is also possible to impose the restriction that the unit under evaluation shall have exactly the same value for some or all of the variables describing the socioeconomic status as the point on the frontier against which it is compared. This will be used in some of the models below. This is modelled by replacing the inequality for  $a$  with a strict equality and can be viewed as not defining whether  $a$  is an input or output. In the next section we discuss the data used for estimating efficiency with the models presented above.

## 4 Efficiency estimation

### 4.1 Previous Models

An approach often seen for modelling education is a description of the production process characterized by quality indicators like mean grades or shares of the students passing exams as output and e.g. teacher/pupil rates as inputs. This approach is used in the DEA setting by e.g. Bessent et al. (1982), Thanassoulis & Dunstan (1994), Smith & Mayston (1987) and Bradley et al. (2001). An alternative approach, more seldom seen in the literature on education but often used in DEA models, is to use total quantities of inputs and outputs. Studies using this approach for education is e.g. Olesen & Petersen

(1995) and Kirjavainen & Loikkanen (1998). The first approach has the advantage of a more direct parallel to earlier studies on school production using regression techniques while aspects like the scale of operation is left out.

As discussed above the production environment is important in DEA models of school production. This can be incorporated in the models in a number of ways. In a value added approach for output Grosskopf, Hayes, Taylor and Weber (see e.g. Grosskopf et al. (2001)) correct the output measure for differences in the socioeconomic status of the students then using a DEA model with quantities as input. The environment is not directly incorporated in the efficiency models. Including the environment as non discretionary variables is primarily done in models using the first of the approaches mentioned above. Standard measures of the environment as the share of students defined into different socioeconomic groups have a natural place in the models. Modelling the production with quantities makes the environmental variables more difficult to use and studies using this approach are more careful with the inclusion of them. One solution is to estimate the importance of the production environment in a second stage regression having the efficiency scores as dependent variable, see Kirjavainen & Loikkanen (1998)<sup>1</sup> and McCarty & Yaisawarng (1993).

In this study we propose ways of incorporating the environment in models using the quantity approach. Also models ignoring the environment and models using teacher/student ratios etc are estimated. Since the objective of the study is not the comparison of models but rather finding explanations for efficiency differences, the models are not compared directly but rather in the second stage analysis.

## 4.2 Data

The problems of measuring school output is well known from research in education. A pure quantitative measure like the number of students graduating has obvious drawbacks since we also want to know what the students have learned. Common in the literature is to use test scores as output. This is not available for Swedish schools so to operationalize knowledge we use students' *grades*. For models using quantities we use the sum of all students' grades for each municipality, constructed as mean grades times enrollment. The reason for not using the mean grades directly is that it does not take the number of students into account when measuring output. We have two other, maybe more indirect,

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<sup>1</sup>Kirjavainen & Loikkanen (1998) include admission level and parent's education as inputs in some models, i.e. in their case these variables are under the control of the school administration.

measures of knowledge in the number of *students passing all subjects* and the number of *students attending higher education*. The first is a measure of how schools take care of the students who need most help in their education. In Sweden socioeconomic weak groups are traditionally given political priority. The number of students attending higher education can be seen as an indication of how well the school has been able to motivate students for continued studies. This measure can of course change both regionally and over time due to unemployment rates etc., but we believe that a good school will influence the student to continue her education, which is often seen as important for economic development.

Examples of traditional inputs are teachers and books, and we use as inputs number of *teachers* and money spent on *teaching material*. However, *premises* is the second most expensive input after teachers and an important factor in the school budget. Teachers and premises amount to about 75% of the total costs for education. A rise in the cost of premises could easily crowd out teaching resources. Premises can be considered as a fixed input in the short run and improving efficiency by changing the use of premises might take some time. It is not impossible however. Increasing the use of space can of course be done by building new schools or rebuilding existing schools to be better suited for modern teaching. Decreasing the use of space is also possible by locating other activities in the school buildings, for example daycare for children. This is a common development in many municipalities wanting to incorporate care for children and early schooling.

The input resources are calculated as mean input per student for the period 1997/98 to 1999/2000 for both primary and secondary school times the number of students graduating secondary school. In this way we do not only take the inputs for the present year into account but also for the years before which of course will influence the grades as well (This problem could be avoided using a value added output, but this is not available for Swedish education).

The most important input in the educational process will be the students themselves and their socioeconomic status (SES) (see e.g. Chubb & Moe (1990), Hanushek (1986), Skolverket (1999)). One way of modelling this is using students and their socioeconomic background as a nondiscretionary input. As discussed above a municipality cannot choose its students and must therefore operate under the conditions given by the students attending the municipal schools. Moreover, students cannot be treated as isolated individuals, but there are substantial external effects between students. This is often referred to as 'peer groups'. Peer groups can be viewed as a form of influence from social background on the working environment. When incorporating socioeconomic variables in the model

we measure inefficiency that is due to school management. Municipalities can in this way be seen as facing different production possibilities or different production frontiers. Important socioeconomic factors are the parents' educational level and the number of immigrant students. Students with highly educated parents will in general achieve higher grades. We divide the student into four socioeconomic groups: *Swedish students with high/low educated parents and immigrant students with high/low educated parents*. A student is defined as immigrant if she is born abroad and/or both parents are born abroad. A student has highly educated parents if at least one of the parents have university education. While the students is a well documented level in educational production, less research has been made on inefficiency in school management at the school level. We therefore do not include school management variables as differences in the production environment for the municipalities directly in the efficiency models but discuss the problem in the second stage statistical analysis.

The data used come from the Swedish National Agency for Education (Skolverket) and is primarily used for comparisons between municipalities after education became a municipal responsibility. The study contains 287 of Sweden's 289 municipalities in 2000<sup>2</sup>. Summary statistics of the variables used in the models are presented in appendix A.

### 4.3 The Efficiency Model

When modelling efficiency we consider three resources (teachers, premises and teaching material) that are used in educating students attending the municipalities' schools. These resources are under the control of local administration and enter our models as variable inputs. The amount of knowledge achieved by students in a municipality is as discussed above hard to measure. As a proxy we use the number of students with complete grades, the number of students attending upper secondary school and the grades of the students.

The environment in the estimated models is included in different ways. In model I we have not taken it into account at all. Part of the inefficiency estimated is thus due to differences in the production environment. In model II we have included two important socioeconomic variables, parents' education and immigrant students. The students are divided into the four socioeconomic groups discussed above. The model forces the unit being evaluated and the frontier to have exactly the same student composition. This

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<sup>2</sup>2 municipalities are omitted due to missing variables. Some municipalities have missing data in one of the years for the input variables. In these cases the mean input for the municipality is calculated without that observation.

ensures that the production environment is equal in the measured variables, but the treatment of the variables is very restrictive. This might imply that the number of municipalities possible to define the frontier for the evaluated unit is limited. One feature of Model II is that the environmental restrictions implies that the municipality under evaluation and the frontier also have the same total number of students. In model III inputs are measured per student and output as mean grades and as shares of the students with complete grades and attending upper secondary school. The environment is defined by the share of the students being Swedish and the share having highly educated parents. By modelling the environment as non discretionary inputs we allow the municipality under evaluation to have a better environment than the frontier in both dimensions. The restrictions thus ensures that the unit has at least as good production environment as the frontier.<sup>3</sup> In Model IV, having a large number of Swedish students is believed to increase output, but the effect might be offset if the municipality has a large number of Swedish students with low education for whom we have no clear idea of their peer effect. To diminish this problem we impose the restriction that the number of Swedish students with high education must exceed that of the frontier. The interaction of the restrictions implies that the unit under evaluation has at least as many Swedish students as the frontier, of which at least as many has high education. The restriction that the number of students with highly educated parents must not fall below that of the frontier works in the same way. This far nothing is said about immigrant students with low education. From the previous literature we believe that this is the weakest group. These students might not increase output due to the formation of bad peer groups or if school resources are not fully compensated for more demanding students. Restricting the frontier to have an equal number of students in this group enables us to estimate efficiency where a low efficiency score is not caused by a high number of the weakest students. The models are shown in Table 1, where X is an input, Y an output and XY is a variable not defined as in or output.

Of course a number of alternative models can be estimated using the same environmental variables. These models are chosen such that Model I and Model II represent one model with no restrictions on the environment and one model with hard restrictions both having positive and negative features briefly discussed above. Model III is estimated in ratio form which is common in the education literature and is also seen in a number

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<sup>3</sup>Model III is, in accordance with the other models, estimated using both CRS and VRS technology. In the CRS technology there is no general guarantee that the frontier does not contain values over 100%, although this is not a problem for our data. For a discussion see Mancebon & MarMolinero (2000).

	<b>Model</b>			
	<b>I</b>	<b>II</b>	<b>III</b>	<b>IV</b>
<b>Variable inputs</b>				
Teachers	X	X	X-per stud	X
Premises	X	X	X-per stud	X
Teaching material	X	X	X-per stud	X
<b>Fixed inputs</b>				
Swedish	-	-	X-%	X
High education	-	-	X-%	X
Swedish - low edu	-	XY	-	-
Swedish - high edu	-	XY	-	X
Immigrant - low edu	-	XY	-	XY
Immigrant - high edu	-	XY	-	-
<b>Outputs</b>				
Complete grades	Y	Y	Y-%	Y
Att upper secondary	Y	Y	Y-%	Y
Sum of grades	Y	Y	Y-mean	Y

Table 1: Estimated models

of DEA applications. The treatment of the environmental variables in Model IV is less restrictive than in Model II, although using quantities implies that additional restrictions are imposed compared to Model III.

The models are estimated using both a CRS and a VRS technology. In the CRS technology we assume that all municipalities can produce in the same way as the most efficient units only scaling the production up or down due to the size of the municipality. If this is not possible a VRS technology better reflects the production possibilities.

Mean efficiency estimated in the models are presented in Table 2.<sup>4</sup> Dependent on which model we prefer the estimated mean efficiency is between 0.872 and 0.956.

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<sup>4</sup>Efficient units having no other reference than themselves are excluded from the analysis. These units are defined as efficient not necessarily because they are good producers but because they are different and thus has no other unit to be compared with.

Efficiency model	Mean efficiency	
	CRS	VRS
Model I	0.872	0.894
Model II	0.941	0.956
Model III	0.897	0.918
Model IV	0.916	0.931

Table 2: Mean efficiency

## 5 Explaining the efficiency scores

We use four areas from economic theory and previous research on education thought to explain the obtained efficiency scores (see section 2): *Competition*, *Political context*, *School characteristics* and *Socioeconomic status*.

Lack of *competition* is a common explanation of inefficiency. Producers acting in a competitive environment are thought to be forced to be efficient in order not to be put out of the market. This is not the case for most of the publicly provided goods, including education. 3% of the Swedish children were attending *private schools* in 2000. However, the number of private schools competing with the public ones is rapidly increasing in Sweden and there is competition not only from the actual competitors but also from potential private schools about to start. Competition does not necessarily increase efficiency since the municipality still have the ultimate responsibility for all students implying that they might have to offset resources in the budget to students who later choose to attend private schools. Our measure of competition is the proportion of students attending private schools in the municipality. When choosing a school for their children, parents also have the possibility to move to an other municipality. This competition is also likely to increase efficiency and we may expect *suburban areas* to be more efficient because they are close both to each other and to a larger city with job opportunities. Families choosing between different suburbs are likely to look for good schools for their children. This behavior is sometimes referred to as the Tiebout effect. To reflect competition from other municipalities we use a dummy for whether the municipality is a suburb or not.

Another area likely to explain efficiency differences is the *Political context* in a municipality. Under this headline is collected a number of variables related to municipal characteristics and to voter characteristics and preferences. The first is the *municipal size* which is likely to influence e.g. monitoring costs and the possibilities for a flexible organization. Size is measured as the number of citizens. We also include *population distance* to capture



efficiency differences due to municipal characteristics not under administrative control. Sweden has many small municipalities with a large population distance and we need to control for this when analyzing the political context. Population distance is measured as average distance in meters between municipal citizens. The socioeconomic status of the voters is assumed to influence bureaucratic efficiency through the monitoring costs. Voters with a low socioeconomic status might have more difficulties reading bureaucratic documents etc and finding the most efficient ways of influencing the bureaucracy. The socioeconomic status of the voters is operationalized as the percentage of the population being *immigrants* (foreign citizens) and the percentage having a *university education* (at least three years of higher education). Municipalities have other responsibilities than education, with care for elderly as the major competitor for funds. A governmental grant system is used to equalize the possibilities for municipalities to provide both education and care for elderly. Differences in expenses can thus be interpreted as a result of political preferences (Söderström (1994)). If we believe in vote maximizing politicians we would suspect that in a municipality with a large proportion of elderly (measured as the proportion of the population being older than *65 years*) politicians will concentrate spendings on care for elderly. With less resources, the schools are likely to be forced to be more efficient. Voter preferences are also shown in their choice of political party. We use a dummy variable for a *socialistic majority* in the municipal council. If the voters' attitude towards inefficiency is reflected in their choice of political ideology we should find efficiency differences between left and right wing voters. With a greater acceptance for inefficiency the benefits from monitoring will be less. Related to political ideology is the financing for municipal activities through taxes. To investigate the influence on efficiency from the tax policy we include the municipal *tax rate* in the analysis. A priori we believe that municipalities with a higher tax rate can afford to be less efficient. Tax rate is the percentage income tax collected by municipalities.

Efficiency differences are likely to occur due to differences in the school sector. One such *school characteristics* is the percentage of teachers with *permanent tenure*. In a principal-agent framework the role of labour contracts is important. Viewing the municipality as agent for the municipal residents the labour contracts of the teachers could be important for an efficient production. We could think of teachers not permanently employed either as not being interested in the long term development of the students and therefore decreasing efficiency or as eager to get a permanent job and therefore performing at least as good as any teacher. Which effect is larger is an empirical question. In order to improve school performance the municipality can hire teachers with formal

*pedagogical skill* who are presumably more productive than unskilled teachers. Teachers permanently employed and teachers with formal pedagogical skill are measured as the proportions of all teachers. We also include the average lunch expenses since it is often claimed that students getting no proper lunch will be tired and thus achieve lower grades. Average lunch expenses are of course not a measure of whether the students are eating or not, but a proxy for the priority of the lunch question in the municipality.

We include the socioeconomic status of the students (*student SES*) in order to control for this when explaining the efficiency for DEA model I not taking environmental differences into account. the variables follow the same definitions as in the DEA analysis.

We summarize our theoretical expectations of the explanatory variables in Table 3.

<b>Variable</b>	<b>Expected sign</b>	<b>Variable</b>	<b>Expected sign</b>
<b>Competition</b>		<b>School characteristics</b>	
Private schools	?	Tenured teachers	?
Suburb	+	Ped skill	+
<b>Political context</b>		Lunch	+
Pop distance	-	<b>Student SES</b>	
Population	?	Immigrants	-
Immigrants	-	University education	+
University education	+		
65+	+		
Socialistic majority	?		
Tax rate	-		

Table 3: Theoretical expectations

Variable definitions and descriptive statistics of the variables are presented in appendix C and D. The data is collected by the Swedish National Board for Education (Skolverket) and the Swedish Bureau of Statistics (SCB). It contains data on 287 municipalities for 2000.

## 5.1 Estimation and Results

When building empirical models explaining the results in the efficiency analysis we follow the discussion above on determinants of inefficiency. By regressing the variables that are theoretically thought to explain efficiency on the estimated efficiency scores we can see whether our expectations hold empirically. This is not straight forward since the

efficiency scores are bounded above by one and therefore OLS regression will be biased and inconsistent. Instead, it is common in the literature to use a Tobit model for censored data.<sup>5</sup> The model is specified as follows

$$\begin{aligned} eff_i &= \beta' X_i + u_i \quad \text{if } eff < 1 \\ &= 1 \quad \quad \quad \text{if } eff \geq 1 \end{aligned}$$

Where  $eff_i$  is efficiency score for municipality  $i$ ,  $X_i$  is the explanatory variables and  $u_i$  is a normally distributed residual with mean 0 and variance  $\sigma^2$ .

Table 4 shows the results for Model II.<sup>6</sup> The other models are presented in the appendix.

We first consider competition from private schools which has no significant influence on efficiency. In a survey of the literature of competition in education and hospital services Söderström & Lundbäck (2000) concludes that many studies on education and competition show that schools increase both efficiency and quality when exposed to competition. Studying the impact of competition on students' outcomes in Sweden Bergstrom & Sandstrom (2001) concludes that a larger part of the students in a municipality that attend a private school, the better is both grades and test scores in the public schools. Grosskopf et al. (2001) find in a study on Texas school districts that competition affects allocative but not technical efficiency. Our results give no indications on competition from private schools affecting efficiency in public education.

Interesting among the political factors is that municipalities with a socialistic majority in the city council are significantly less efficient. Skolverket (1996) find that municipalities with a socialistic majority have greater expenses per student which according to our results are not only due to greater output, but also to an inefficient production. The result is consistent with a hypothesis that voters with a socialistic ideology are more tolerant

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<sup>5</sup>The Tobit model is used by e.g. McCarty & Yaisawarng (1993) and Kirjavainen & Loikkanen (1998) for school data. For a discussion on the assumption see e.g. McCarty and Yaisawarng (1993).

<sup>6</sup>Heteroscedasticity is found in the models (MIICRS LR= 17.29 and MIIVRS LR=11.73 are Chi-squared distributed with 4 df, see Greene (1997)) why the presented coefficients are estimated in a Tobit model using

$$\sigma_i = \sigma \exp(\gamma z_i)$$

where  $z$  consists of the variables population, pop distance, immigrant voters and univervisty educated voters. Normality is tested with a conditional moment test, see e.g. Greene (1997) p 971. The test statistic is chi-square distributed with 2 df. The VRS model has problems with non normality.

<b>Variable</b>	<b>MIICRS</b>		<b>MIIVRS</b>	
	<b>Coeff.</b>	<b>P-value</b>	<b>Coeff.</b>	<b>P-value</b>
Constant	-0.0398	0.8586	-0.1987	0.4510
<b>Competition</b>				
Private schools	0.0010	0.6652	0.0002	0.9517
Suburb	0.0374	0.1368	0.0422	0.2083
<b>Political context</b>				
Pop distance	-0.0064	0.8871	0.1112	0.0854
Population	0.0001	0.5586	0.0008	0.0981
Immigrants	0.4365	0.1976	0.0850	0.7808
University education	0.2059	0.5127	0.1780	0.7332
65+	0.0335	0.9014	-0.1135	0.7461
Socialistic majority	-0.025559	0.0425	-0.0199	0.2302
Tax rate	0.0025	0.7288	0.0033	0.7131
<b>School factors</b>				
Perm tenured teachers	0.3722	0.0211	0.5423	0.0092
Teachers educated	-0.4278	0.0055	-0.4257	0.0336
Lunch	-0.0075	0.5044	-0.0012	0.9346
<b>No of observations</b>	253		224	
<b>Normality test</b>	LM = 4.00	0.1353	LM = 10.85	0.0044

Table 4: Tobit Model with Efficiency Estimated Using Model II as Dependent Variable

to inefficiency in public provision of services. We find no evidence of local tax rates influencing efficiency. The socioeconomic status of the voters (immigrant and university education) give no significant results in the models. The hypothesis that socioeconomic status influences monitoring costs and thereby efficiency seems not to hold. However, the variables are correlated to the students socioeconomic status and since efficiency in DEA Model II is estimated in relation to municipalities with similar students the effect might not show in the second stage results.

The principal-agent framework highlights the role of wage contracts. Viewing municipal employees as agents for the voters to provide education, the way e.g. teachers are employed is important. Teachers permanently tenured has a significant positive sign in our models. This implies that, through some mechanism, municipalities offering their teachers a permanent position at a school will be better at providing education with a

low input use. A second result concerning the teachers is that municipalities employing teachers with a formal pedagogical education are less efficient than others. This is of course not consistent with the a priori expectations, but could be explained by e.g. that the pedagogical education affects the way grades are set or that skilled teachers have better opportunities to choose working in a municipality that have more input resources. Although the municipality is the formal employer of the teachers, the individual school managers have influence over the decision. Inefficiency due to teacher contracts and teacher skill should not be entirely attributed to the municipal managers. The result thus indicates that the actual inefficiency caused by municipal managers are somewhat overestimated in the DEA models.

The results from the alternative efficiency models are similar to Model II. As expected the students' SES are important for explaining efficiency in Model I where no account was taken to this in the efficiency estimation. Immigrants show a significant negative sign and university education a significant positive. For Models III and IV the share of immigrant voters seem to have a weak positive effect of efficiency. The alternative models all indicate a positive influence from Tiebout competition, i.e. suburbs are more efficient.

## 6 Conclusions

The paper estimates efficiency in the provision of public education by Swedish local government (municipalities). The efficiency models are based on theories of education as a multilevel production process. The estimated mean efficiency is between 0.872 and 0.956. This implies that the municipalities can decrease their inputs with approximately 4-11% on average and still produce the same outputs.

From economic theory on e.g. bureaucratic inefficiency a number of possible explanations to the estimated efficiency are found. In the analysis we find evidence of municipalities with a socialistic majority in the city council being less efficient. This can be viewed as the voters in these municipalities having higher tolerance to inefficient production. We also find evidence of teachers' employment contracts affecting efficiency, where many permanently tenured teachers increases efficiency. Teachers with formal pedagogical training seems on the other hand to decrease efficiency.

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# Appendix

## A Variable Definitions - Efficiency Models

<b>Variable</b>	<b>Definition</b>
Teachers	Mean number of full time equivalent teachers in t to t-2 per student in the municipality times the number of graduating students. Data source: Skolverket, Jämförelsetal för skolhuvudmän
Premisies	Mean space in square meters per student in t to t-2 times the number of graduating students. Data source: Skolverket, Jämförelsetal för skolhuvudmän
Teaching material	Thousand SEK per student in t to t-2 times the number of graduating students. Data source: Skolverket, Jämförelsetal för skolhuvudmän
Immigrant students	Students born abroad or with both parents born abroad. Data source: Skolverket
Parents education	Education of the highest educated parent where 'high education' corresponds to university education. Data source: Skolverket
Complete grades	Number of students passing all subjects. Data source: Skolverket, Jämförelsetal för skolhuvudmän
Upper secondary	Number of students attending secondary school. Data source: Skolverket, Jämförelsetal för skolhuvudmän
Sum of grades	Mean grades times the number of graduating students. Data source: Skolverket, Jämförelsetal för skolhuvudmän

Table 5: Variable Definitions

## B Summary Statistics - Efficiency Models

	Mean	Std. dev.	Min	Max
<b>Variable inputs</b>				
Teachers	25	39.29	3	470
Premisies (m2)	4 995	7493.24	560	98 458
Teaching material (Thousand SEC)	826.06	2243.18	37.37	36 361.28
<b>Fixed inputs</b>				
Swedish - low education	163	168.53	16	1 703
Swedish - high education	123	211.09	7	2 634
Immigrant - low education	33	93.06	0	959
Immigrant - high education	16	45.05	0	553
Number of students	335	498.43	27	5 849
<b>Output</b>				
Complete grades	254	366.91	23	4 277
Att upper secondary school	297	430.85	26	5 024
Sum of grades	67 858	102 804.27	6 085	1 226 920

Table 6: Summary statistics

## C Definitions - Explanatory Variables

Variable	Definition
Private schools	Share of students in the municipality attending private schools 2000. Data source: Skolverket, Jämförelsetal för skolhuvudmän
Suburb	Dummy variable: 1 for suburbs and 0 otherwise. Data source: Statistiska centralbyrån (SCB)
Pop distance	Population density in meters. Data source: Skolverket, Jämförelsetal för skolhuvudmän
Population	Mean number of citizens 2000. Data source: SCB, Sveriges statistiska databaser, Befolkning efter kommun, civilstånd och kön
65+	Share of the population over 65 years 2000. Data source: SCB, Kommunfolkmängd 31/12 2000 efter ålder och kön
Socialistic majority	Dummy variable: 1 for socialistic majority, 0 otherwise. Data source: Skolverket, Jämförelsetal för skolhuvudmän
Tax rate	Municipal income tax rate. Data source: SCB, Utdebitering 2000
Tenured teachers	Mean share of teachers with permanent tenure in t to t-2. Data source: Skolverket, Jämförelsetal för skolhuvudmän
Pedagogical skill	Mean share of teachers with formal pedagogical skill in t to t-2. Data source: Skolverket, Jämförelsetal för skolhuvudmän
Lunch	Mean expenditure (SEC) for school lunch per student in t to t-2. Data source: Skolverket, Jämförelsetal för skolhuvudmän
Voters, immigrant	Share of municipal population being foreign citizens 2000. Data source: SCB, Sveriges statistiska databaser, Befolkning efter kommun, civilstånd och kön
Voters, education	Share of municipal population having university education 1999. Data source: SCB, Sveriges statistiska databaser, befolkning 16-74 efter kommun, utbildningsnivå och kön.

Table 7: Variable Definitions

## D Summary Statistics - Explanatory Variables

	Mean	Std. dev.	Min	Max
<b>Competition</b>				
Private schools	2.2296	3.2802	0	17.6
Suburb	0.1254	0.3318	0	1
<b>Political context</b>				
Pop distance (km)	0.2768	0.2674	0.017	2.045
Population (thousand)	30.6281	57.9346	2.721	747.026
65+	0.1894	0.0373	0.0825	0.2924
Socialistic majority	0.3937	0.4894	0	1
Tax rate	21.1089	1.2183	16.18	23.57
<b>School characteristics</b>				
Tenured teachers	0.8471	0.0456	0.6813	0.9503
Ped skill	0.8923	0.0494	0.71	0.9866
Lunch	3.4381	0.6352	2.2	5.9167
<b>Voter SEC</b>				
Immigrants	0.0382	0.0276	0.0081	0.2691
University education	0.0526	0.0265	0.0239	0.2191
<b>Student SEC</b>				
Immigrants	0.0997	0.0703	0	0.4576
University education	0.3625	0.0970	0.1171	0.8185

Table 8: Summary statistics of the explanatory variables

## E Explaining Efficiency in Model I<sup>7</sup>

Variable	MICRS		MIVRS	
	Coeff.	P-value	Coeff.	P-value
Constant	-0.2772	0.0737	-0.2805	0.0956
<b>Competition</b>				
Private schools	-0.0013	0.3950	-0.0024	0.1854
Suburb	0.0326	0.0614	0.0373	0.0809
<b>Political context</b>				
Pop distance	-0.1205	0.0002	-0.0620	0.0560
Population	-0.00003	0.6902	0.0006	0.0035
65+	-0.0051	0.9768	0.1026	0.6219
Socialistic majority	-0.0331	0.0007	0.6219	0.0004
Tax rate	-0.0002	0.9745	-0.0023	0.6757
<b>School characteristics</b>				
Perm tenured teachers	0.4798	0.0001	0.4123	0.0019
Teachers educated	-0.2288	0.0434	-0.1851	0.1406
Lunch	-0.0104	0.2255	0.0003	0.9716
<b>Student SES</b>				
Immigrants	-0.3306	0.0000	-0.2846	0.0035
University education	0.1507	0.0033	0.1533	0.0123
<b>No of observations</b>	287		283	
<b>Normality test</b>	LM = 4.22	0.1210	LM = 9.95	0.0069

Table 9: Tobit Model with Efficiency Estimated Using Model I as Dependent Variable

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<sup>7</sup>The heteroscedasticity test described for Model II earlier has test statistic LR = 30.26 for MICRS and LR = 24.15 for MIVRS (both with 4 df), why also these Tobit models are estimated with correction for heteroscedasticity. The VRS model has problems with a non normal error distribution.

## F Explaining Efficiency in Model III<sup>8</sup>

Variable	MIICRS		MIIVRS	
	Coeff.	P-value	Coeff.	P-value
Constant	-0.2592	0.1292	-0.0799	0.6543
<b>Competition</b>				
Private schools	-0.0020	0.2337	-0.0021	0.2311
Suburb	0.0534	0.0067	0.0432	0.0430
<b>Political context</b>				
Pop distance	-0.0813	0.0236	-0.1019	0.0009
Population	0.0001	0.7526	-0.00004	0.8129
Immigrants	0.3779	0.1372	0.5172	0.0332
University education	0.2577	0.2610	-0.0628	0.7787
65+	0.2593	0.1836	0.1916	0.3537
Socialistic majority	-0.0382	0.0010	-0.0217	0.0462
Tax rate	0.0021	0.7156	-0.0035	0.5452
<b>School characteristics</b>				
Perm tenured teachers	0.4139	0.0020	0.3402	0.0067
Teachers educated	-0.2752	0.0303	-0.2116	0.0689
Lunch	-0.0120	0.2084	-0.0129	0.1785
<b>No of observations</b>	278		272	
<b>Normality test</b>	LM = 11.79	0.0028	LM = 5.04	0.0803

Table 10: Tobit Model with Efficiency Estimated Using Model III as Dependent Variable

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<sup>8</sup>The heteroscedasticity test has test statistic LR = 30.51 for MIICRS and LR = 13.72 for MIIVRS (both with 4 df), why also these Tobit models are estimated with correction for heteroscedasticity.

## G Explaining Efficiency in Model IV<sup>9</sup>

Variable	MIVCRS		MIVVRS	
	Coeff.	P-value	Coeff.	P-value
Constant	-0.3561	0.0409	-0.3942	0.0279
<b>Competition</b>				
Private schools	-0.0011	0.5571	-0.0027	0.1603
Suburb	0.0417	0.0480	0.0191	0.4078
<b>Political context</b>				
Pop distance	-0.0477	0.2558	0.0476	0.3100
Population	0.0003	0.0914	0.0005	0.0178
Immigrants	0.3777	0.0414	0.3015	0.0916
University education	0.1663	0.4789	0.5363	0.0570
65+	0.2283	0.2566	0.0418	0.8566
Socialistic majority	-0.0292	0.0144	-0.0233	0.05575
Tax rate	0.0051	0.3950	0.0053	0.3861
<b>School characteristics</b>				
Perm tenured teachers	0.5615	0.0000	0.4439	0.0027
Teachers educated	-0.3689	0.0047	-0.2418	0.0766
Lunch	-0.0096	0.3493	0.0006	0.9531
<b>No of observations</b>	275		268	
<b>Normality test</b>	LM = 14.93	0.0006	LM = 14.99	0.0006

Table 11: Tobit Model with Efficiency Estimated Using Model IV as Dependent Variable

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<sup>9</sup>The heteroscedasticity test has test statistic LR = 17.43 for MIVCRS and LR = 24.90 for MIVVRS (both with 4 df), why also these Tobit models are estimated with correction for heteroscedasticity.