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EFFICIENCY AND PRODUCTIVITY IN FINNISH COMPREHENSIVE SCHOOLING 1998–2004

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Abstract: This study measures efficiency differences and productivity changes of Finnish municipalities providing comprehensive school education during 1998–2004 by estimating both production and cost functions. The average inefficiency was approximately 6–10 percent during 1998–2004 based on both production and cost function estimations. Both approaches also produced very similar inefficiency rankings for the municipalities. Based on the results of cost functions, both the size of the municipality and average school size had a nonlinear impact on costs. The optimal municipal size was approximately 24 000–37 000 inhabitants and optimal school size was 690 students. The share of students in remedial instruction, the share of students using transportation, and taxable income per inhabitant had a positive impact on costs whereas the share of students in lower school decreased the costs. The productivity of the comprehensive schools decreased on average 12 percent during the period. The increase in per capita taxable income and the share of students in remedial instruction had the biggest impact on the productivity decrease whereas the increase in school size clearly enhanced productivity.

Key words: Comprehensive education, efficiency, productivity

Tiivistelmä: Tutkimuksessa selvitettiin kunnallisen perusopetuksen tehokkuuseroja ja tuottavuuskehitystä vuosina 1998–2004 estimoimalla sekä tuotanto- että kustannusfunktioita. Tehottomuus oli keskimäärin 6–10 prosenttia tarkastelujaksolla sekä tuotanto- että kustannusfunktioiden perusteella. Molemmat lähestymistavat tuottivat hyvin samanlaiset tehottomuuslukujen mukaiset kuntien paremmuusjärjestykset. Kustannusfunktioiden tulosten perusteella sekä kunnan että koulujen keskimääräinen koko vaikuttivat epälineaarisesti kustannuksiin siten, että kustannukset minimoiva kunnan koko oli keskimäärin 24 000–37 000 asukasta ja optimaalinen koulujen koko oli noin 690 oppilasta. Erityisopetusta saavien oppilaiden osuus, kuljetettavien oppilaiden osuus ja kunnan asukaskohtaiset verotettavat tulot vaikuttivat kustannuksiin positiivisesti kun taas suurempi ala-asteella olevien oppilaiden osuus pienensi kustannuksia. Perusopetuksen tuottavuus laski tarkastelujaksolla keskimäärin 12 prosenttia. Asukaskohtaisten verotettavien tulojen ja erityisopetusta saavien oppilaiden osuuden kasvu vaikuttivat eniten tuottavuuden laskuun. Koulujen keskimääräisen koon kasvu puolestaan nosti tuottavuutta.

Asiasanat: Perusopetus, tehokkuus, tuottavuus

Contents

1. Introduction

In Finland, heavy investments on education during the past decades have resulted in dramatic improvement of the overall educational level. In particular, young Finns are today among the best educated in the world. Recently, Finnish 15 year-olds have also proved to be among the leading pupils in internationally standardised assessments of reading, mathematics and science literacy (The OECD Programme for International Pupil Assessment (PISA)).

Not surprisingly, all this has not come without cost. The total education expenditure has grown remarkably since 1950s and presently the share of education expenditures per GDP is one of the highest in OECD countries. Especially the expenditure per pupil in higher education ranks among the top. On the other hand, the expenditure per pupil in basic education is still below OECD average. One can then say that the Finnish comprehensive school system provides excellent results with average expenditures.

In many countries, the educational sector has received a great deal of attention both academically and politically. Especially the production issues and efficiency differences among schools and providers of education have been the subject of number of studies during the past decades. Most of such research have estimated the production function by describing the average relation between inputs and outputs (see e.g. Hanushek (1986 and 2003), Krueger (2003) and Hedges & Greenwald (1996)).

Since 1980s the frontier methods, based on Farrell's (1957) original work, have become more commonly used. The methods can be divided into stochastic and non-parametric ones. Stochastic methods have the advantage of allowing statistical tests and interference. In education, a growing number of studies estimate the efficiency of schools applying stochastic frontier methods (see e.g. Barrow (1991), Deller & Rudnicki (1993), Cooper & Cohn (1997), Heshmati & Kumbhakar (1997), Mizala *et al*. (2002)).

Data Envelopment Analysis (DEA), first formulated by Charnes *et al*.'s (1978), is a nonparametric method that has been widely used in the context of education. The main advantage of DEA over stochastic methods is the ability to handle multiple inputs and multiple outputs. In addition, it does not require any assumption about the production technology. No information of prices of inputs and outputs showing their relative importance is needed since the method calculates optimum weights for each observation.

The early DEA studies on educational production have mainly concentrated on detecting efficiency differences between schools, school districts or, as in UK, Local Education Authorities (see e.g. Bessent & Bessent (1980), Bessent *et al*.

(1982), Ludwin & Guthrie (1989), Jesson *et al*. (1987) and Smith & Mayston (1987), Bonesrønning & Rattsø (1994) and Kirjavainen & Loikkanen (1993)). In recent years, most of the studies have explained the efficiency differences (Bradley *et al*., 2001, Duncombe *et al*., 1997, Grosskopf *et al*., 2001, Kirjavainen and Loikkanen, 1998).

In Finland, the focus in education has so far been mainly on teaching and pedagogical issues, not on economics of education. Nevertheless the question of efficiency and productivity issues has been raised as recent population forecasts show that the number of pupils will be reduced dramatically during the following decades. Therefore, some structural decisions need to be made.

The general purpose of this paper is to provide new information on the efficiency differences and productivity changes of Finnish comprehensive school education during 1998–2004. To our knowledge, this is the first study on this topic using Finnish data. Due to data problems the analysis is carried out not on school but on municipal level. The outputs are depicted with very rough measures such as the number of pupils, number of pupils continuing their studies in secondary education, and the grades of the comprehensive school certificate. As an input we use operating expenditures.

We use two alternative methods to measure efficiency: Data envelopment analyses (DEA) and stochastic frontier analysis (SFA). This procedure allows us to test the robustness of the efficiency differences. In the first phase, we start with the education production function and calculate efficiency scores for each municipality with DEA. Thereafter, we explain the differences in efficiency scores by various environmental and operational variables using both cross section and panel data. In the second phase, we estimate education cost functions with SFA and examine how different environmental and operational variables affect the costs of the municipalities. At the end of the paper we also estimate some education production functions with stochastic frontier analysis using PISA test scores as output.

The paper proceeds as follows. In section two we describe the Finnish schooling system in short. In section three we discuss the theoretical aspects and in section four we describe the estimation methods. Section five summarises the data used in the study. Section six presents the results from the DEA analysis and section seven the stochastic frontier results. Section eight presents results from an analysis using PISA results as an output. Section nine provides short summary of the results.

2. The Finnish comprehensive school system

The nine-year comprehensive school starts in the calendar year a child turns seven. The pupils in comprehensive school are usually aged between 7 and 15.[1] Comprehensive schooling is divided into primary education (grades 1–6) and lower secondary education (grades 7–9). Each school prepares their own curriculum based on the national core curriculum published by Finnish National Board of Education. There are no national tests at the end of comprehensive school.

In 2004 there were 3 450 comprehensive schools and the pupil population was some 565 000. Compared to many other countries, comprehensive schools are small. Average school size was 160 pupils in 2004 and only some 20 percent of schools had more than 300 pupils.

Local governments have a major role in education sector in Finland. Most comprehensive schools in Finland are maintained by the municipalities. Private schools account for less than one percent of schools and one percent of pupils. In addition to education services, municipalities also provide social welfare, health services and local infrastructure services.

Comprehensive school expenditures form about 13 percent of total municipal operating expenditures. The schools are financed by municipalities with tax revenues and general block grants received from the state. For the pupils, the comprehensive education, as all education in Finland is free of charge, including study materials, a daily warm meal, school health and dental care. Pupils who live far from the school are entitled to free transportation.

Previous studies on municipal service expenditures in Finland have shown that the income effect is higher in case of education expenditures than in other municipal expenditure categories (Moisio, 2000). This may reflect the fact that education is highly valued public service not only at the central government level, but also at municipal level.

[1] Municipalities can also provide additional teaching in the form of a voluntary tenth grade.

3. Theoretical considerations

In economics, the evaluation and measurement of efficiency is based on the concept of production function. It describes the physical and technical relations involved in the production. The function defines the maximum set of outputs at the given level of inputs and production technology.

The general production theory gives a solid foundation to analyse public service production. Considerable modifications need, however, to be made to take the special characteristics of each service type such as education into account. In education, the relationship between inputs and outputs has been studied in the production function environment since the mid 1960's (Coleman *et al*., 1966). Here, we follow Duncombe et al. (1995) to define the basic production process in education as:

(1) $G = f(L_T, L_P, K, Z)$,

where G depicts direct services or educational activities provided by the schools, L_T is teachers, L_P other staff, K buildings and other major capital equipment and Z other material factor inputs. In education it is, however, extremely difficult to measure outputs which present quantities of activities of equivalent quality (e.g. classroom hours at a given level of instruction).

The quantity and quality of purchased inputs and the direct activities produced by schools are only of indirect interest for the decision-makers in the municipalities. The main interest of parents and voters is targeted at pupil achievement and learning. Hence, it is more desirable to concentrate on service outcomes measured e.g. on achievement in some standardized test. In such a case, in determining these outcomes parental background and pupil characteristics play important role (see e.g. Hanushek, 1986 and 2003). Therefore, we define pupil achievement S and environmental inputs E affecting the pupil achievement as:

(2) $S = g(G, E)$,

(3) $E = h(P, F, ST)$.

The environmental factors can be grouped into three categories: physical characteristics P, family background F and pupil characteristics ST. The physical characteristics of schooling can be described for example with the number of pupils and the average school size in the municipality. Family background plays an important role in education process as proved by education production function studies, and therefore one need to take it into account. Usually it is described with variables like parental income, education, and other parental resources and expectations. Pupil characteristics are related to such factors as innate ability and motivation. Their use in education production function studies is, however, uncommon because of measurement problems. One can try to describe pupil characteristics with e.g. pupils with learning disabilities or non-native origin. Substituting (3) into (2) gives us the implicit production function for schooling:

(4) $S = g(G, h(P, F, ST))$.

The production function defined above can be used to derive a cost function. Using the duality between cost and production functions we can use the standard production function (1) to solve the implicit cost function:

(5) $TC = c(G, W)$,

where W is the input prices and TC is total costs. Solving G in (4) and substituting it in (5) we can write the cost function to fit the educational production:

(6) $TC = c(h^{-1}(S, g(P, F, ST)), W)$.

The cost function above provides us a flexible way to analyse the cost of education outcome. In addition to the above factors, we should take the demand for educational services into account. Factors related to the demand of education include municipalities' fiscal capacity as well as other indicators for preferences for schooling.

It should be noted at this point that unfortunately in this study we are not able to use pupil achievement as our outcome measure. This is because we do not have good quality information on pupil achievement for all municipalities. At best, this information is available only for limited number of municipalities. Instead, our outcome measures are related to the school grades given by teachers and to the continuation of studies at the upper secondary level. We also use the number of pupils as a rough physical outcome measure. Despite these weaknesses, we think that the above model fits our case.

4. Methods

4.1 Data Envelopment Analysis

Data Envelopment Analysis (DEA) is an application of linear programming that can be used to calculate relative technical efficiency in case of multiple inputs and outputs. This is done by deriving an efficiency frontier as a linear combination of inputs and outputs of efficient observations in the sample. Each observation is either at or below the frontier so that observations (in our case schools or municipalities) at the frontier are efficient and have efficiency score of 1 (or 100 per cent). The efficiency scores of observations below the frontier depend on their distance to the frontier and vary between 0 and 1 (or 100 per cent). The weights and efficiency are defined simultaneously so that each observation will get maximum efficiency within its comparison observations.

The DEA efficiency scores can be calculated either assuming constant (CRS) or variable returns to scale (VRS). In practice, the size of the decision-making unit may either increase or decrease the efficiency. It is not, however, possible to detect the efficiency caused by the scale of the operations only by observing inputs and outputs. If the observations at the efficiency frontier are of different sizes, the assumption of constant returns to scale is, however, good enough description about the production possibilities.

The DEA efficiency scores are possible to calculate either by assuming that the observations minimize their use of inputs or that they maximize the amount of outputs. In this study, we assume that the observations minimize the use of inputs. Let us consider *n* observations where observation *j* uses the amount of x_{ij} of input *i* and produces the amount of y_{rj} output *r*. Then, by denoting the input weights by v_i (i=1,…,m) and the output weights by μ_r (r =1,…,s) and by constraining them to be greater than an infinitesimal ε (in order to ensure unique solution), our basic DEA linear programming problem for the observation j_0 can be written as:

$$
\begin{aligned}
&\max_{\mu,\nu} \sum_{r=1}^{s} \mu_r y_{rj_0} \\
&s.t. \quad \sum_{i=1}^{m} v_i x_{ij_0} = 1 \\
&\sum_{r=1}^{s} \mu_r y_{rj} - \sum_{i=1}^{m} v_i x_{ij} \le 0 \qquad j = 1,\ldots,n. \\
&\mu_r, v_i \ge \varepsilon
\end{aligned} \tag{7}
$$

Model (1) maximizes the efficiency score for the observation j_0 so that the score varies between [0,1]. Each observation gets the optimal weights for inputs and outputs so that they are non-negative.

As mentioned earlier, the optimal weight structure is an advantage of DEA. It can, however, cause some problems. It might be the case that for some observations the calculated weight is close to zero so that the variable doesn't contribute to the efficiency. It is also possible that the differences in weights for certain inputs or outputs are large which is also not desirable (see e.g. Charnes *et al.*, 1995 and Coelli *et al.*, 1999). To avoid these problems it is possible to impose constraints on the relative magnitude of the weights for desired inputs or outputs. In so-called Assurance Region DEA model (AR-DEA see e.g. Cooper *et al.*, 2000) lower and upper bounds are set on the ratio of weights for e.g. selected outputs r and k:

$$(8) \qquad L_{r,k} \le \mu_k / \mu_r \le U_{r,k} \Leftrightarrow \begin{cases} \mu_k - L_{r,k}\mu_r \ge 0 \\ -\mu_k + U_{r,k}\mu_r \ge 0 \end{cases} \qquad r,k \in \{1,\ldots,S\},$$

where $L_{r,k}$ and $U_{r,k}$ are lower and upper bounds respectively. These constraints determine the marginal rate of substitution between the selected outputs. In some studies the constraints are set based on information on market prices (see e.g. Aaltonen *et al.*, 2004 and 2005). In this study, such information was not available for the comprehensive schooling. We, therefore, set quite wide constraints for the outputs just to ensure that for each observation the efficiency score is determined by all outputs. The description of the weight constraints follows in Appendix (Figure 11).

4.2 Models explaining DEA efficiency

As DEA models usually do not include environmental variables, it is customary to perform a second stage analysis for the DEA efficiencies. In practice, one estimates an explanatory model for DEA efficiencies in order to control for the environment and other relevant factors.

DEA efficiency scores are bounded between 0 and 1 (or 100 per cent). Therefore, Tobit-model is usually an appropriate estimation technique when the explanatory variable is bounded at the upper end (in our case the efficiency). In Tobit-models the likelihood function is discrete so that there is a separate likelihood function for the truncated observations (observations at the frontier) and for inefficient observations. However, if the number of observations at the frontier is small, the difference between the likelihood function of the Tobit-model and likelihood function derived from the normal distribution is also small. Nevertheless, in this paper we use Tobit model to ensure unbiased estimates.

In panel data models fixed or random effects models are the most commonly used estimation methods. The choice between these two depends mainly on whether the unobserved individual effect is correlated with all explanatory variables or not: in case of no correlation we can use random effects model. However, often the unobserved effect cannot be assumed to be noncorrelated with explanatory variables and, hence, one is expected to use fixed effects estimation (See e.g. Wooldridge, 2002).

4.3 Stochastic frontier models

Stochastic frontier analysis (SFA) is a parametric method to estimate technical inefficiency, first introduced by Aigner, Lovell and Schmidt (1977) and Meeusen and van der Broeck (1977).

SFA was the first method to allow for technical inefficiency and random shocks in the frontier model. This was in contrast to (deterministic) frontier methods introduced before SFA, where all variation in output not associated with variation in inputs was attributed to technical inefficiency.

SFA can be applied to both production and cost frontiers. In the former case one uses an output-oriented approach and in the latter case the input-oriented approach. SFA on production frontier requires information on input use and output provision. The estimation of cost efficiency requires information on input prices, output quantities and total expenditure on the inputs used. Overall, there are several important differences between the estimation of output-oriented technical efficiency and input-oriented cost efficiency. In this paper we estimate cost efficiencies. Hence, in the following we shortly discuss only this approach. More detailed discussion on SFA can be found from Kumbhakar and Lovell (2000).

Cost frontier approach assumes that each decision making unit tries to minimize the cost in producing a given level of output. In this framework, the stochastic cost frontier for the cross-sectional data can be written as (Kumbhakar and Lovell, 2000, 136-139):

(9) $$E_i \geq c(y_i, w_i; \beta) \cdot \exp\{v_i\},$$

where $E_i = \sum_n w_{in} x_{in}$ is the expenditure of producer i, y_i is a vector of outputs produced by producer i, w_i is the vector of input prices faced by producer i, $c(y_i, w_i; \beta)$ is the cost frontier common to all producers, and β is a vector of technology parameters to be estimated. The stochastic frontier consists of deterministic part $c(y_i, w_i; \beta)$ that is common to all producers, and the producer-specific random part $\exp\{v_i\}$.

If we assume that the cost model is of a single output[2] log-linear Cobb-Douglas form, then the stochastic frontier can be written as:

(10) $$\ln E_i \geq \beta_0 + \beta_y \ln y_i + \sum_n \beta_n \ln w_{ni} + v_i$$
$$\ln E_i = \beta_0 + \beta_y \ln y_i + \sum_n \beta_n \ln w_{ni} + v_i + u_i ,$$

where v_i is the two-sided random noise component distributed as iid $N(0, \sigma_v^2)$, and u_i is the nonnegative cost inefficiency component distributed as iid $N^+(0, \sigma_u^2)$, of the composed error term $\varepsilon = v_i + u_i$. It is also assumed that v_i and u_i are distributed independently of each other and of the regressors. A measure of cost efficiency CE_i is provided by $\exp\{-u_i\}$.

The error term ε is positively skewed if $u_i \geq 0$. Before continuing with the cost efficiency analysis, one then needs to test the skewness assumption, for example with the test proposed by Coelli (1995). If the tests do not suggest skewness, then there is no evidence for technical inefficiency in the data (Kumbhakar and Lovell, 2000, 72-74).

In case positive skewness of u_i exists, then one can proceed with the analysis. However, the situation is complicated by the fact that there are several alternative distributional possibilities for u_i to use in SFA, of which the most customary ones are half normal, exponential, truncated normal and gamma distributions. The half-normal distribution assumption is the most common one used in frontier studies, but there is no "a priori" justification for the selection of any particular distributional form. Tests have been developed to aid the selection (see for example Coelli, Rao, Battese, 1999; Kumbhakar and Lovell, 2000).[3] It is likely that sample mean efficiences are sensitive to the distribution used for u_i. However, it is less likely that the ranking of the units analysed is affected by the distribution used (Kumbhakar and Lovell, 2000, 90).

The estimated cost frontier model may include the environmental variables and quality variables directly in the cost function as estimators. In this case one assumes that the environmental and quality factors influence the shape of the technology so that the estimated inefficiency scores are net of environmental influences. A second possibility would be to model the environmental factors so that they influence the inefficiency term rather than the shape of technology

[2] Multiple outputs and information on input quantities makes possible to formulate a model where cost frontier would be treated as a component of a simultaneous equation model with cost share equations. In this case it is possible to obtain municipality-specific estimates of the magnitude and cost of technical efficiency and allocative efficiency (see Kumbhakar & Lovell (2000), p136-166). The problems with single output models have been discussed recently by Kumbhakar and Wang (2006).

[3] One can, for example, take the truncated normal distribution assumption of u_i: $u_i \sim$iid $N^+(\mu, \sigma_u^2)$ and test the H_0: $\mu = 0$. If the null is not rejected, then the density function collapses to the half normal density function.

(Battese and Coelli, 1995, Coelli et al., 1999). The estimated inefficiency scores from this method incorporate the environmental effects and can be seen as gross technical efficiency scores. Both approaches are reasonable, and the final decision always depends on the judgement of the researcher.

Heteroscedasticity is a potential source of bias in technical inefficiency estimates and in the estimates of either of the error components. This is especially the case if the u_i is heteroscedastic. If just v_i is heteroscedastic, the bias is found only in technical inefficiency scores. If both terms are heteroscdastic, the effect is unclear as they may cancel out each other (see Kumbhakar & Lovell, 2000).

In case of panel data, the analysis includes also the time dimension:

$$(11)\quad \ln E_{it} = \beta_0 + \beta_y \ln y_{it} + \sum_n \beta_n \ln w_{nit} + v_{it} + u_i ,$$

where t is the time subscript. When analysing panel data with frontier analysis it is often assumed that the cost inefficiency is time invariant ($u_{it} = u_i$). This is potentially a questionable assumption, especially with long panels (Greene 2005a). One can test the time constancy of cost inefficiency parameters by comparing the results from a truncated-normal frontier model with a test that is based on modelling the inefficiency effects as:

$$u_{it} = \exp\{-\eta(t-T_i)\}u_i.$$

If the H_0 that $\eta=0$ is accepted, then the model can be reduced to time invariant model. If $\eta>0$ then the degree of inefficiency decreases over time, if $\eta<0$, the degree of inefficiency increases over time (STATA 8.0 manual, p. 65-73).

Another common assumption when estimating frontiers with panel data has been that individual heterogeneity is interpreted as inefficiency. However, this may be an unjustified assumption as shown by Greene (2005a, 2005b). Therefore, it is important to try to separate the inefficiency effect from heterogeneity. This can be done with the so called true fixed effects and true random effects estimators proposed by Greene (2005a, 2005b). True fixed effects model can be written as:

$$(12)\quad \ln E_{it} = \beta_i + \beta_y \ln y_{it} + \sum_n \beta_n \ln w_{nit} + v_{it} + u_{it} ,$$

This is the same model as above except that now we have β_i in the model instead of β_0 and u_{it} instead of u_i. In other words, we estimate separate individual effect for each unit and with this technique we are able to estimate the DMU and time specific inefficiency effect that is separated from heterogeneity.

In sum, the Stochastic Frontier Analysis (SFA) allows for both the random error and technical inefficiency. This is in contrast with DEA, where all unexplained differences in expenditures are assumed to be inefficiency. Further, being a parametric method, SFA enables statistical inference. The disadvantage using stochastic frontier compared to DEA is the need to assume an explicit functional form for technology and a given distribution for inefficiency.

On the other hand, DEA scores are very sensitive to errors in the data and to the selection of input and output variables. In DEA models, there always has to be at least one fully efficient unit, but in most cases there is more than one efficient unit. DEA cannot rank these efficient units. In SFA models there doesn’t have to be any fully efficient units at all.

5. Data

In this study, we use municipal level data to evaluate the efficiency of comprehensive school education. Our data consists of all municipalities providing lower (grades 1–6) and upper (grades 7–9) school education in 1998–2004 in Finland. In order to maintain comparability, municipalities providing only lower school education were dropped. That left us with 359–362 municipalities depending on the year. Schools maintained by the state, hospital schools and schools for handicapped were also excluded from the data.

The data is combined from different registers. The expenditure information is obtained from the VALOS-register maintained by the Finnish National Board of Education. The information on number of pupils, pupils completing their grade, pupils graduating, number of Non-Finnish -speaking pupils and number of pupils receiving remedial instruction was obtained from the register maintained by Statistics Finland. The Joint Application Register provided us information on grade point average for those completing comprehensive school. The number of pupils admitted to upper secondary education (upper secondary or vocational school) directly after completing comprehensive school was also obtained from this register.

5.1 Input and output variables in DEA models

In this study, we use two input variables and four output variables in our DEA models. As inputs we use teaching expenditures and other expenditures of municipal comprehensive schools. The other expenditures consist of meals, health care and counseling, administration, transportation, accommodation, and rents for the school properties. All the expenditures are deflated to 2004 price level using the price index of public spending in municipal education. The operating expenditures have increased partly because there was a reform in the pension insurance system that was implemented gradually since 1998. In order to take this into account, we deflated expenditures with chained deflator. The base year in the first deflator was 1995 and in the latter one 2000.

As output variables we use the number of pupils in 1.–6. grades, the number of pupils in 7. and 8. grades, grade point averages of comprehensive school certificates (multiplied with the number of graduates), and number of pupils admitted to upper secondary education (upper secondary or vocational school).

With the number of pupils we measure the volume of the municipal comprehensive schooling. We use separate output variables for pupils in lower (grades 1 to 6) and upper level (grades 7 to 9) of comprehensive school, because the class size and subjects vary between the two levels and therefore also the use of resources may vary.

The grades of the comprehensive school graduates are used to measure the achievement of pupils. They are the grades given by teachers. Since the grading practices differ somewhat between the schools there is some systematic bias in the grades.[4] With the use of standardized test results this problem could have been avoided. Unfortunately, such data is not available for the whole school age cohort in Finland. Even though the grading practices vary at the individual and school level, these differences are likely to balance off at the municipal level.

With the number of pupils admitted to secondary schooling we measure the effectiveness of the schools. Naturally, the background of pupils, their personal attitude and the distance to the nearest educational institution affects the decision to continue studies at the upper secondary level. But also the school can influence the attitudes of the pupils using e.g. personal counselling. Therefore, this variable measures at least to some extent the success of schools in encouraging their pupils for further studies. The summary statistics of input and output variables are reported in the Appendix (Table 11).

5.2 Explanatory variables used in production and cost functions

We use three different types of variables in explanatory models. These are local environmental factors, municipalities´ financial situation, and characteristics of pupils and schools. The list of the variables is in Table 1.

[4] Finnish National Board of Education has also published guidelines for good grading practices in order to harmonize them in different schools.

Table 1 *Variables used in the study*

Abbreviation	Description
Teaching costs	Salaries and teaching materials (books etc)
Other costs	Meals, administration, health and counseling, transportation, accommodation, and rents for the property
Average salary	Average salary of all workers in municipal comprehensive education sector
Grade point average (GPA)	The grade point average of comprehensive school certificates
% Upper secondary schooling	The share of pupils admitted to vocational or upper secondary schools
Number of pupils	All pupils in the municipality excluding disabled pupils
% in remedial instruction	The disabled pupils are not included
% Pupils using school transportation	Share of pupils using transportation and accommodation
% Pupils in grades 1–6	Share of pupils in lower schools
% Non-Finnish -speaking pupils	Share of pupils whose native language is not Finnish
Taxable income/inhabitant	Deflated with consumer price index
Average school size	Average number of pupils
Education index	Measures level of education of the total adult population in the municipality (measured in years of completed schooling) *100
% Socialists in the council	The share of social democrats and other left-wingers in the council
Coastal area	Three categorical variable; 0 = no island, 1 = partly island, 2 = wholly island
Secondary school (dummy)	0=no upper secondary school in the municipality, 1= upper secondary school located in the municipality

Local environmental factors such as geographical location and population density set some limits for the organization of the comprehensive schooling in the municipality. These factors are not under the control of the municipality but affect considerably the way the schooling can be organized and therefore it also influences the DEA-efficiency and expenditures. These factors should be controlled for when comparing municipalities. We measure the local environment with *number of pupils, the educational level, unemployment rate and a dummy variable for municipalities located in the coastal areas*. We assume that the first factor has a positive effect on DEA-efficiency and negative effect on expenditures and the last two are assumed to decrease DEA-efficiency or increase expenditures. As for the educational level we do not make a priori assumption of the sign of the effect.

The variety of education services provided by the municipality may also create scale effects. We test these effects by including a *dummy variable for upper secondary school,* which controls for municipalities with both the comprehensive schools and upper secondary school in their area.

The overall economic situation of the municipality influences its spending level. In a tight economic situation spending may be cut down and vice versa. We measure the economic situation of the municipality with *the municipal tax base measured as per capita taxable incomes*. We assume that higher tax base induces looser spending and increases expenditures or decreases DEA-efficiency.

The characteristics of the pupils also affect the use of resources. Finland is officially a bilingual country and therefore in all municipalities teaching in comprehensive schools is provided in both languages, Finnish and Swedish. In Lapland, there is also instruction in Sámi language. In addition, especially in larger cities the number of immigrants is increasing. All these factors create additional pressures to school spending. As a measure of pupil population requiring instruction in different languages we use the *share of Non-Finnish -speaking pupils*.

Municipalities are obliged to provide special and remedial instruction for pupils needing it. Especially in recent years the number of pupils in remedial instruction has increased dramatically. Remedial instruction is more expensive than 'normal' instruction and therefore it also increases expenditures and lowers the DEA-efficiency. We measure the degree of remedial instruction with the *share of pupils in remedial instruction*.

The instruction in lower level and upper school differs to some extent. Class size is usually smaller in lower school. In upper school there is, however, wider selection of subjects. It is not completely clear, how these differences influence the use of resources and DEA-efficiency. We control *the share of pupils at the lower school* and make no assumption about the sign of the variable.

The share *of pupils using transportation and accommodation* is a variable which demonstrates quite well the structure of the school network in municipality. We assume that as the share of pupils using transportation and accommodation increases the total expenditure per pupil increases and DEA-efficiency decreases. It is obvious that in sparsely populated municipalities transportation expenditures are greater than in densely populated municipalities.

School size is another variable related to the organization of comprehensive schooling in the municipality. We expect that there is some scale effects involved in the schooling and hence, the DEA-efficiency is higher or expenditures are lower in larger schools. As a measure for school size we use *average school size* and *school size squared* in the municipality.

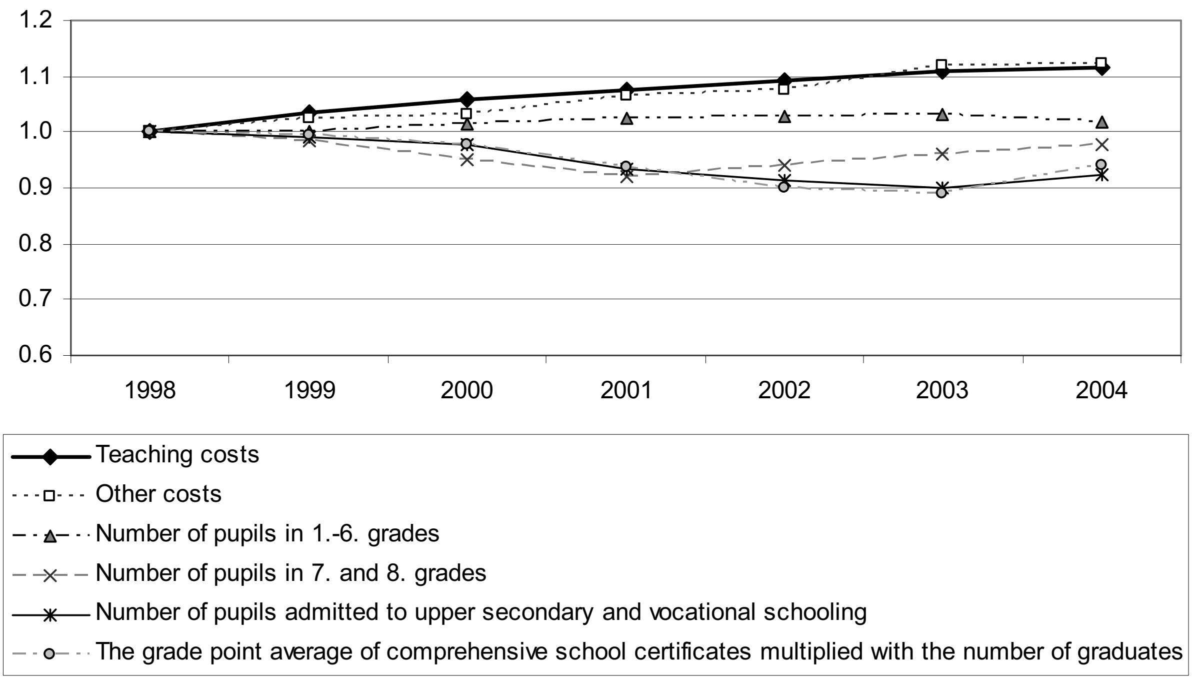
The political situation in the municipality affects the spending decisions. In economic literature, high share of socialist representatives in the council are often assumed to result in increased public spending. We test this assumption by including the *share of socialist representatives in the council* as one explanatory variable.

Finally, because the wages and the structure of teaching staff differ somewhat between municipalities, we use the *average wage level of the teaching staff* in the municipality as a control variable in the models.

5.3 Changes in inputs and outputs in 1998–2004

The comprehensive school expenditures increased some 12 % in real terms in 1998–2004 (Figure 1)[5]. The operating expenditures increased partly because of the reform in the pension insurance system in the late 1990s. However, the effect of the pension system is not crucial as without social insurance fees, pension insurance fees and paid pensions the expenditures rose approximately 9 % between years 1998–2004.

Figure 1 Changes in inputs and outputs in 1998–2004



The number of pupils at the lower schools rose 2 %. At the same time, the number of pupils at the upper schools decreased some 3 %. Number of pupils admitted to upper secondary and vocational schooling has decreased approximately 8 %. The diminishing age cohorts cause mostly the decline. In other words, the share of pupils admitted to upper secondary and vocational schooling has remained quite stable. The share of the pupils admitted to upper

[5] Teaching expenditures constitute a major share of the total operating expenditures, approximately 65 % every year.

secondary schools right after graduation is around 60 % and to vocational schools around 35 %. There are some gender differences in the choices since almost half of the boys and only fourth of the girls apply to vocational education. Some five per cent of the age group does not continue their studies directly after completing comprehensive school.

The GPA multiplied by the number of graduating pupils has decreased 6 % in 1998–2004. The falling number of graduating pupils causes the decline since the grades of comprehensive school certificates have remained almost unchanged.

6. Education production function: a two stage approach

6.1 Efficiency differences in comprehensive education

In this chapter we apply DEA[6] to calculate the efficiency scores for each municipality (Table 2). We use both constant (CRS) and variable returns (VRS) to scale assumptions in calculations. The tests we performed on the scale effects showed strong evidence on increasing returns to scale. Nevertheless, we report the results from both models as a sensitivity check of the results due to different assumptions.[7]

According to DEA results, the average efficiency in comprehensive school education was 81 percent assuming VRS and 77 percent assuming CRS in 1998–2004. In other words, the average municipality was 19–23 percent less efficient than the most efficient municipalities. The standard deviation of efficiency scores remained almost unchanged over the years. The number of municipalities at the efficiency frontier was the same for each year except for 2004. Also the municipalities at the efficiency frontier have remained almost unchanged from year to year.

Table 2 DEA efficiency scores of comprehensive schooling in 1998–2004

Year	Average efficiency CRS	Average efficiency VRS	Lower quartile CRS	Lower quartile VRS	Upper quartile CRS	Upper quartile VRS	Std. deviation CRS	Std. deviation VRS	Number of efficient units CRS	Number of efficient units VRS
1998	0.75	0.81	0.68	0.75	0.84	0.88	0.11	0.10	5	13
1999	0.75	0.80	0.67	0.74	0.83	0.86	0.11	0.10	3	16
2000	0.78	0.81	0.70	0.74	0.86	0.89	0.11	0.10	7	20
2001	0.78	0.81	0.71	0.74	0.86	0.88	0.10	0.11	4	19
2002	0.79	0.81	0.72	0.74	0.87	0.88	0.11	0.10	5	16
2003	0.79	0.81	0.73	0.75	0.85	0.88	0.10	0.10	4	11
2004	0.79	0.81	0.73	0.74	0.87	0.88	0.11	0.10	2	4

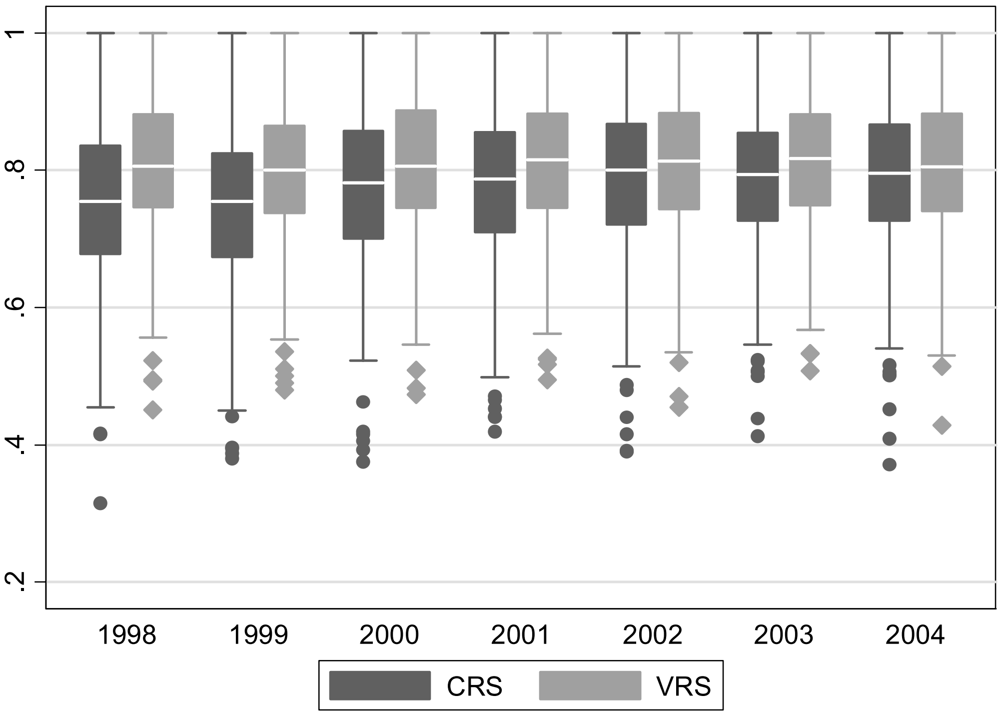
The calculated efficiency differences between municipalities were large in each year as the efficiency scores of the least efficient municipalities were less than 50 % (Figure 2). In other words, these units use double the amount of money to

[6] We used EMS 1.3 program to calculate DEA efficiency scores.

[7] As mentioned earlier, we have used weight restrictions for outputs, and they are described in Appendix (Figure 11).

produce the same output as the most efficient units. In CRS-model the efficiency differences have slightly diminished towards the end of the period, but in VRS-model there is no such trend.

Figure 2 *The median and range of DEA-efficiency scores in 1998–2004**



*In Figure 2 the boxes depict 50 % of efficiency score distribution. The upper bound of the box depicts the upper quartile and the lower bound of the box the lower quartile of the data. The line in the middle of the box is the median value. The length of the lines above and below the boxes is at most 1.5 times quartile deviation. The observations below the lines deviate over 1.5 times the quartile deviation and they are considered as outliers.

6.2 Explaining the DEA efficiency differences

As shown above, there were considerable efficiency differences between the municipalities. However, the DEA models used did not contain any of the environmental or pupil characteristic variables that we described in section 5.2. Therefore, in order to find out which factors affect the efficiency differences we estimate explanatory models of the efficiency for individual years (cross-section models) and for the whole period (panel data models). We explain the efficiency differences and productivity change with variables relating to demographics, overall economic situation, and characteristics of pupils of the municipalities. We also have some measures for the organization of the comprehensive schooling in the municipality. The estimation method we use is Tobit which was described in more detail in section 4.2.

6.2.1 Results of cross-section estimations

As expected, the *average salary of teaching staff* affected negatively on efficiency every year except in 2004 (Table 3). As for the characteristics of pupils, the *share of non-Finnish speaking pupils* affected negatively on efficiency in years 1998–1999 and 2001–2002. This variable controls for the higher costs for providing the instruction in two languages and for the non-native pupils. The *share of the pupils at remedial instruction* has a negative but non-significant effect in most years. Furthermore, the *share of pupils using school transportation and accommodation* had a negative effect on efficiency in every year. As expected, the larger the distances in the municipalities the less efficient it is controlling for e.g. the average school size.

Average school size has always a positive effect on efficiency. In other words, there seems to be clear scale effects involved with larger school size. We also tested the functional form of the effect and in most of the years it turned out to be non-linear except in years 2003 and 2004.

The effect of the size of the pupil population measured with *number of pupils* is found to be non-linear for all the years. In other words, for most municipalities the efficiency increases as the number of pupils increases but after reaching the "optimal size", the efficiency starts to decline. In 2004, the calculated optimal size was 3300 pupils.[8]

The education level of the municipality did not have any effect on efficiency. The wealthier the municipality in terms of *taxable income/inhabitant* the more money it spends on comprehensive education. This shows up in our estimations as decreasing efficiency.

The *share of the socialist representatives* in the council did not have statistically significant effect on efficiency, except for year 2001. However, the coefficient is very small so that the calculated effect is also very small. In most of the years *the coastal location* did not have statistically significant effect on efficiency. In addition, it did not seem to matter to efficiency whether or not the municipality also maintained *upper secondary school*.

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[8] We also tested the municipal population as alternative to number of pupils and found that the optimal municipality size for the year 2004 was about 24 000 inhabitants.

Table 3 *The determinants of DEA-efficiency in cross-section models (CRS models) in 1998–2004*[9]

	1998	1999	2000	2001	2002	2003	2004
Average salary	-0.211	-0.189	-0.238	-0.212	-0.252	-0.187	-0.134
	(4.17)**	(3.17)**	(3.76)**	(3.76)**	(4.68)**	(3.28)**	(2.22)*
No. of pupils	0.146	0.221	0.169	0.159	0.202	0.133	0.116
	(3.06)**	(4.51)**	(3.32)**	(3.94)**	(4.86)**	(2.99)**	(2.79)**
Square no. of pupils	-0.010	-0.015	-0.013	-0.011	-0.013	-0.009	-0.007
	(2.40)*	(2.08)*	(1.77)	(2.72)**	(3.47)**	(1.39)	(1.61)
% in remedial instruction	0.034	0.363	0.26	0.092	0.281	0.255	0.294
	(0.11)	(1.26)	(0.99)	(0.44)	(1.40)	(1.23)	(1.45)
% Pupils transported	-0.142	-0.115	-0.081	-0.156	-0.103	-0.109	-0.128
	(4.04)**	(3.07)**	(2.07)*	(4.59)**	(2.96)**	(2.94)**	(3.49)**
% Non-Finnish -speaking pupils	-0.051	-0.046	-0.042	-0.056	-0.076	-0.031	-0.035
	(2.40)*	(2.08)*	(1.77)	(2.72)**	(3.47)**	(1.39)	(1.61)
Taxable income/inhabitant	-0.076	-0.056	-0.076	-0.132	-0.082	-0.119	-0.069
	(1.94)	(1.39)	(1.80)	(3.37)**	(2.01)*	(2.59)*	(1.68)
Average school size	0.635	0.569	0.314	0.506	0.408	0.248	0.282
	(4.91)**	(4.39)**	(2.36)*	(4.21)**	(3.32)**	(1.86)	(2.18)*
Square average school size	-0.046	-0.043	-0.016	-0.037	-0.028	-0.012	-0.017
	(3.33)**	(3.09)**	(1.11)	(2.86)**	(2.16)*	(0.88)	(1.24)
Education index	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	(0.12)	(0.52)	(1.41)	(1.25)	(0.08)	(0.36)	(0.86)
% Socialists in the council	-0.010	-0.017	-0.005	-0.067	0.052	-0.036	-0.047
	(1.90)	(0.49)	(0.12)	(2.04)*	(1.53)	(1.00)	(1.29)
Costal area	-0.010	-0.022	-0.012	-0.001	0.003	-0.002	-0.002
	(1.10)	(2.36)*	(1.18)	(0.13)	(0.33)	(0.19)	(0.20)
Upper secondary school (dummy)	-0.016	-0.015	0.004	0.008	-0.005	0.007	0.001
	(1.61)	(1.40)	(0.35)	(0.84)	(0.44)	(0.63)	(0.07)
sigma: Constant	0.06	0.065	0.069	0.06	0.064	0.068	0.067
	(26.56)**	(26.65)**	(26.52)**	(26.56)**	(26.55)**	(26.55)**	(26.70)**
Constant	0.712	0.259	1.603	1.554	1.545	2.013	1.194
	(1.29)	(0.42)	(2.36)*	(2.50)*	(2.54)*	(3.05)**	-1.76
Observations	360	360	362	359	360	359	360
Right Censored	5	3	7	4	5	4	2
Pseudo R^2	-0.90	-0.77	-0.71	-0.76	-0.72	-0.52	-0.57

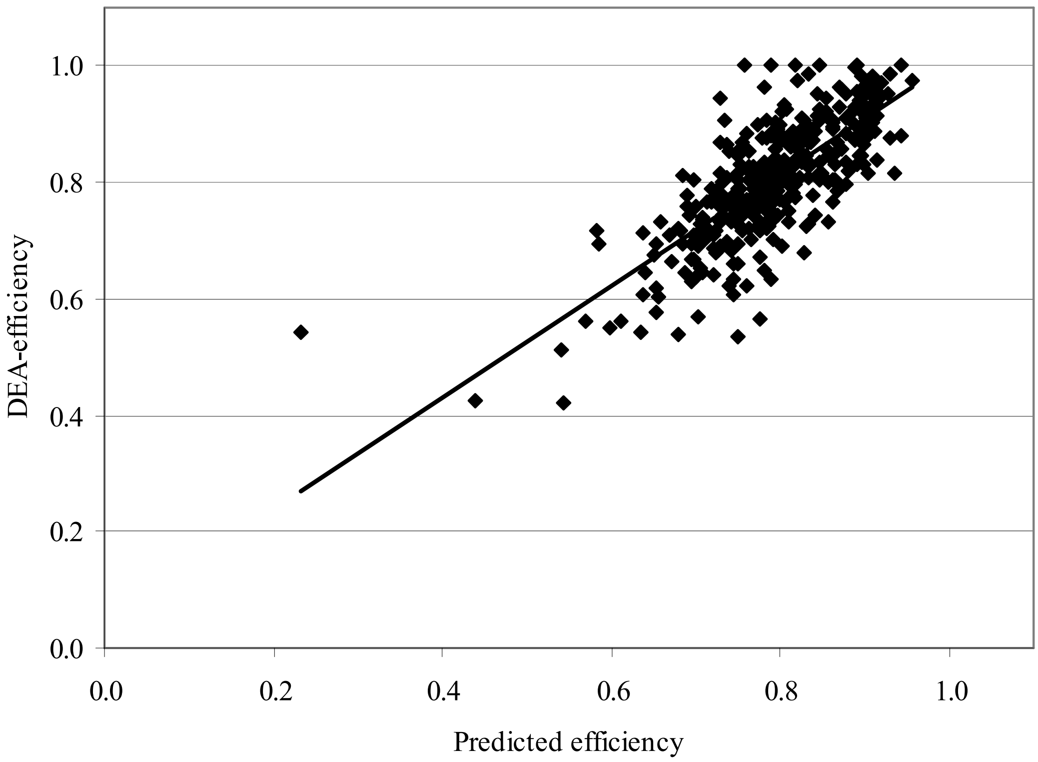
Absolute value of t statistics in parentheses
* significant at 5%; ** significant at 1%

In Figure 3 we compare the results of DEA and the results obtained with our explanatory model for the year 2004. The DEA efficiency scores are depicted in x-axis and the estimated efficiency scores in y-axis. There is a high correlation between the DEA efficiency scores and the predicted scores. The performance of some municipalities may considerably differ though. Controlling for the environmental factors, some of the municipalities perform ‘better than expected’

[9] All explanatory variables in logarithmic form except ratios.

so that their predicted efficiency is lower than the DEA efficiency score. These municipalities are, in other words, more efficient than other municipalities with similar conditions. Correspondingly, there are municipalities that perform worse than expected. In these municipalities the predicted efficiency is higher than the DEA efficiency score. One reason behind these differences between expected and realized efficiencies could be e.g. the diversity in managerial practices and courses offered within municipalities, which we could not control for in the cross section models.

Figure 3 *DEA efficiency score and predicted efficiency score in 2004*



6.2.2 Results of panel data estimations

Next, we will present the results of models using panel data. We use the same explanatory variables but test their effect on changes in productivity. As dependent variable we use the efficiency of municipalities based on one common efficiency frontier for the whole period 1998–2004. We estimate fixed effects models[10], which capture the time invariant municipality effect (see e.g. Wooldridge, 2002).

The results of panel estimations are presented in Table 4. We estimate two different models which differ only so that in the second model the yearly dummies are included.[11] The yearly dummies control for macroeconomic factors that vary over time and are common for all municipalities. The size of the effect of each explanatory variable on productivity is shown in column 3 and the average change of the variable over the period is in column 4.

Almost all the variables in the model are statistically significant and they explain 44 % of the variance in efficiency scores without the fixed effects. From the variables characterising pupils the *share of non Finnish-speaking pupils* and *pupils using transportation and accommodation* were statistically non-significant in explaining the changes in efficiency. Since there is very little variation in these variables over the period analysed it is quite evident that their coefficients remain statistically insignificant.

The share of the pupils receiving special or *remedial instruction* affected negatively on efficiency. The growth of the share has decreased productivity[12] on average 2.3 percentage points. This result is quite obvious because remedial instruction is clearly more expensive than normal instruction.

The *average salary of the comprehensive school staff* has a negative effect on productivity but it is not statistically significant and during 1998–2004 the effect on productivity has been very small.

According to the results, *number of pupils* have a negative effect on efficiency except for the municipalities with the highest pupil growth rates, where the effect is reversed. So even though we already found that there is a clear positive relationship between number of pupils and efficiency[13], we find decreasing marginal efficiencies. The change in the number of pupils increased the productivity in 1998-2004 about 1.8 percentage points.

The effect of *taxable income* per inhabitant was negative in the panel models in the same way as in the cross section data. Taxable income per inhabitant has

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[10] Since our data consists of all the comparable municipalities we use the fixed effects models in our panel data estimations. We also tested the model specification with the Hausman specification test and the results showed that the fixed effects model was more appropriate than the random effects model.

[11] In model 2 the coefficients of the yearly dummies measure the change in efficiency (the level of productivity) compared to base year 1998.

[12] Calculation method is presented in Appendix Table 14.

[13] In the cross section data, we find that efficiency and the number of pupils had a positive relationship up to a point after which the efficiency started to decrease again (Table 3).

increased almost 11.5 % in 1998–2004. Based on our calculations, the increase in taxable income has decreased the productivity on average by 2 percentage points.

The average *school size* and efficiency have a positive relation and an increase in school size had a positive effect on productivity. The magnitude of the effect was 4.4%.[14]

The growth of the *educational level* of the municipal population had a small negative impact on the efficiency of comprehensive schooling. We do not have any clear explanation for that. As for the change in productivity, this variable has had only marginal effect on efficiency.

The year dummies reported in Table 4 show that the *average efficiency* declined between years 1998–2004 by 9.2 percentage points. The coefficient for the dummy variable indicating year 2004 measures the difference between base year 1998 and the year 2004 in efficiency levels. The productivity development from 1998 to 2004 can be calculated by dividing the change in average efficiency level (9.2) by the average efficiency in base year 1998, which is 77 percent. We find that the *productivity* of comprehensive schooling decreased on average by 11.9 percent between years 1998-2004 (Figure 4).[15]

[14] We also tested the effect of the amount of teaching provided by municipality (teaching hours/pupil) on productivity. According to our results the effect was on average small. The descending productivity cannot be explained by increase in teaching.

[15] The results are similar even though we exclude taxable income per capita and education index from the model.

Figure 4 Productivity development 1998–2004

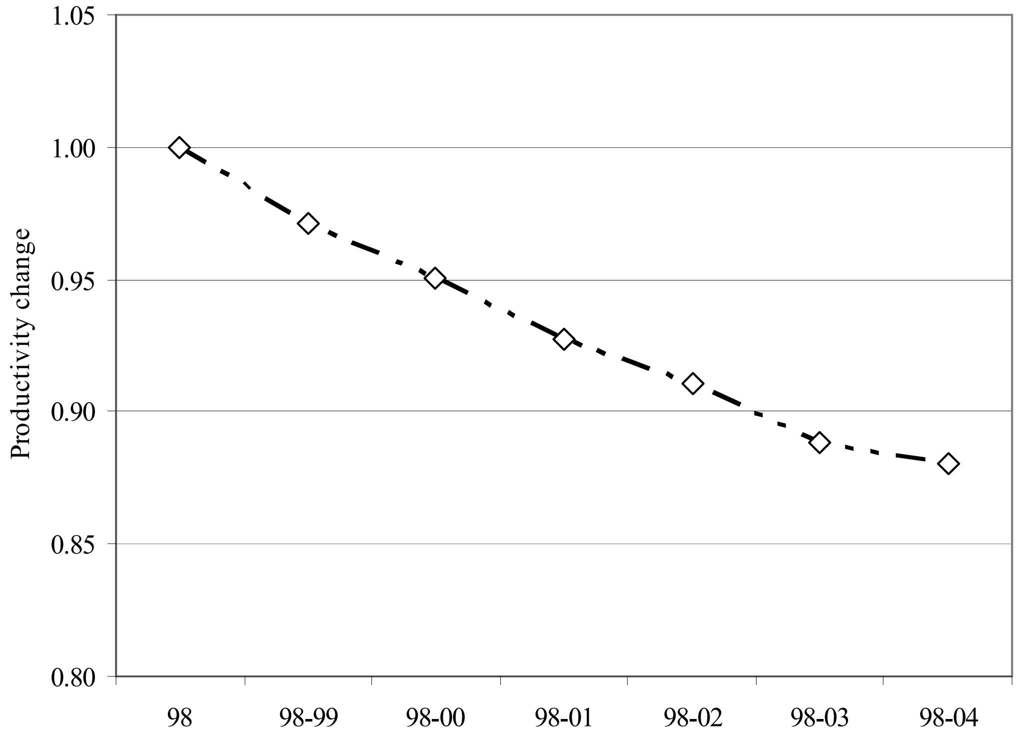


Table 4 The results of panel data models

	Model1	Model2	Impact on productivity	Average change
Average salary	-0.034	-0.015	-0.05	1.14%
	(1.66)	(0.79)		
No. of pupils	-0.177	-0.255		
	(2.13)*	(3.28)**	1.80	-8.32%
Square no. of pupils	0.012	0.016		
	(2.00)*	(2.80)**		
% in remedial instruction	-0.571	-0.074	-2.26	2.79
	(6.79)**	-0.89		
% Pupils transported	-0.002	0.016	-0.01	1.98
	(0.07)	(0.60)		
% Non-Finnish -speaking pupils	-0.105	-0.17	0.00	0.02
	(0.83)	(1.45)		
Taxable income/inhabitant	-0.123	0.06	-2.00	11.46%
	(4.26)**	(2.09)*		
Average school size	0.506	0.394		
	(6.68)**	(5.57)**	4.40	7.53%
Square average school size	-0.048	-0.036		
	(5.83)**	(4.65)**		
Education index	-0.002	-0.000	-0.08	32.93
	(14.79)**	(1.34)		

Table 4 Continued: the results of panel data models

v99		-0.022
		(8.85)**
v00		-0.038
		(13.24)**
v01		-0.056
		(16.26)**
v02		-0.069
		(16.31)**
v03		-0.086
		(17.11)**
v04		-0.092
		(14.04)**
Constant	1.827	0.296
	(3.94)**	(0.67)
Observations	2520	2520
Number of nro	368	368
R-squared	0.44	0.52
F-test for regression coefficients	F(10.2142)= 169.07	
F-test for fixed effects	F(367.2142)= 17.59	
Hausman-test	chi2(10)= -826.77 P>chi2=0.000	

Absolute value of t statistics in parentheses
* significant at 5%; ** significant at 1%

7. Education cost function: stochastic frontier analysis

In this chapter we apply the stochastic frontier analysis, which was described in section 4.3, to estimate cost function of comprehensive schooling. We estimate both cross section and panel data frontier models and report the test results and parameter estimates. At the end of this chapter we compare the results of cost functions with SFA and production function with DEA and explanatory model.

When formulating the cost function in this study, we assume that municipalities take the number of pupils as exogenously given, and provide the education service with minimum costs. In other words, municipalities use inputs so that the cost of providing services is minimized.[16] In order to keep the analysis as simple as possible we treat the model as one output cost model that is derived from Cobb-Douglas production function. Hence, we base our cost function frontier analysis on a single-equation model. The main reason we choose to do this instead of formulating a multiple output translog cost functions is that we do not have good quality information on input quantities, such as number of teachers and other staff. In addition, we do not have information on the physical characteristics of schools such as building space etc. Because of these data limitations, we would not be able to formulate proper cost share equations. Hence, we concentrate on obtaining the parameters describing the structure of cost frontier, and on estimating municipality-specific inefficiency effects.

The data and variables used in the frontier estimations are more or less the same than those used in the explanatory models for the efficiency scores obtained with DEA. The cost variable we use here is the *operating expenditures per pupil*. The single-output variable is the *number of pupils.* We treat the *grade point average*, and *share of pupils who continued their studies in upper secondary and vocational schools* as output quality measures. We describe the pupil characteristics with *share of pupils in remedial instruction*, *share of pupils using transportation*, *share of pupils in lower school* and *share of non Finnish-speaking pupils.* In addition, we control for a variety of environmental factors (at the municipal level) such as *wealthiness*, the *average school size*, *educational level of local population*, *political situation*, *coastal location*, and whether there is also a *upper secondary school in the same municipality*. All variables are transformed into natural logarithms before estimations, if they are not in the percentage mode.

For data reasons described earlier in this paper, the analysis is carried out at municipal level. As we have data for 357 municipalities for years 1998–2004, we utilise the panel nature of the data as much as possible. We start the analysis with

[16] Note that in our DEA calculations we made the input orientation assumption based on the idea that the decision variable for the municipalities is inputs (expenditures) not output (number of pupils).

cross-section analysis, however. We estimate frontier-regressions for each cross-section year using the half-normal, truncated-normal, and exponential distribution assumptions. For each cross-section, we test the presence of inefficiency, the distributional assumptions, and the heteroscedasticity of idiosyncratic errors v_i and the inefficiency terms u_t.

In panel data models we estimate pooled panel and fixed effects models using various distributional assumptions. We test for time variance of the inefficiency effects by comparing the results from a truncated-normal frontier model with time-invariancy assumption and the Battese-Coelli (1995) model where time effects are allowed. More importantly, we also follow Greene (2005a, 2005b) to separate the heterogeneity from inefficiency effects using the so called true fixed effects approach. We report the estimated parameters, summary of inefficiency scores as well as rank correlations among the different methods for these panel models.

We choose to include the environmental variables to the production function because we feel that the environmental variables do affect directly the comprehensive school production. In addition, the net inefficiency scores indicate directly the managerial performance which is desirable for our purposes (Coelli et al., 1999).

7.1 Cross-section frontier estimations

We estimate frontier regressions for years 1998–2004 using the following cost model:

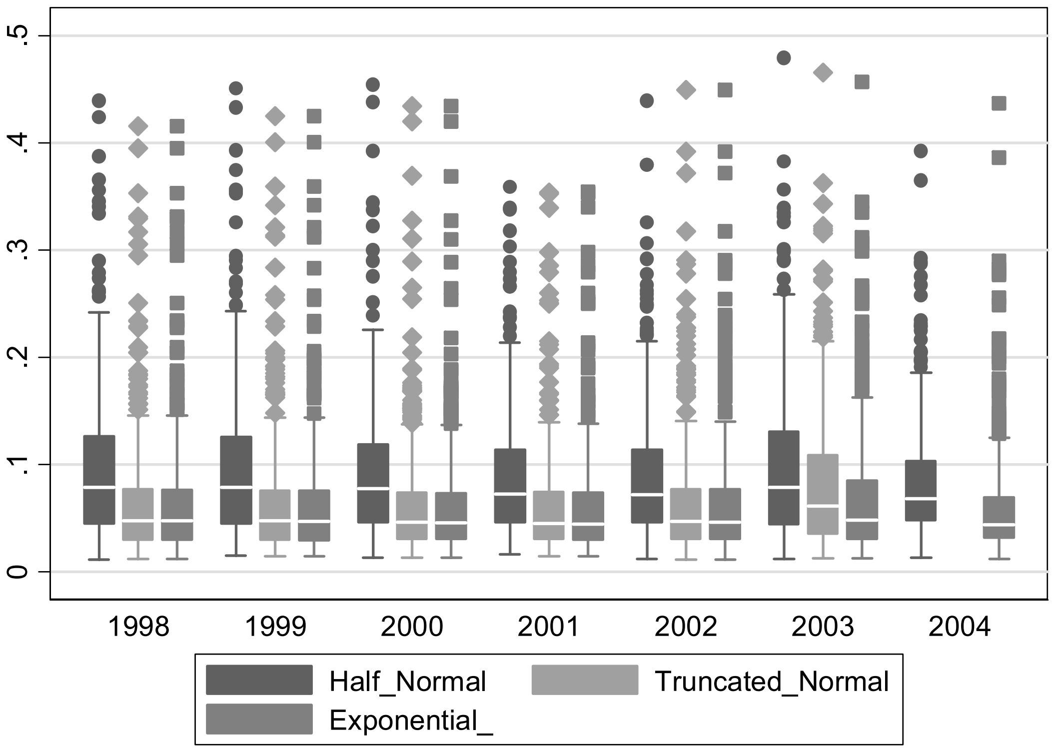
$$\ln E_i = \beta_0 + \beta_y \ln y_i + \beta_z \ln w_i + \sum_k \ln \beta_k x_{ki} + v_i + u_i ,$$

where $\ln E_i$ is the log of the expenditure per pupil of municipality i, β's are parameters to be estimated, $\ln y_i$ is the log of output (number of pupils), $\ln w_i$ describes the average wage of the school personnel faced by municipalities i, $\ln x_{ki}$ are the k explanatory variables including environmental variables, v_i is the idiosyncratic error term, and u_i is the cost inefficiency term. As usual, we assume that v_i and u_i are distributed independently of each other, and of the regressors.

As for the results of the estimations, we can first note that using the one-sided test for the presence of inefficiency term (Coelli, 1995), we can reject the null hypothesis of no inefficiency component for all the cross-section years 1998–2004. With this result we proceeded with the analysis. In order to get a picture of the effects of different distributional assumptions on u_i, we estimated frontiers using the half-normal, truncated-normal and exponential distributions.

According to the results, the frontier estimation with half-normal distribution assumption produces two to three percentage point higher average inefficiency scores compared to the truncated-normal or exponential distribution assumptions[17] (in the first case the measured average inefficiency was about 8 percent and in the latter two cases 5 percent). Also, the variation of inefficiency scores is higher with half-normal distribution (Figure 5). The differences between truncated-normal and exponential distributions are very small except for 2003 (for 2004 the truncated normal model did not converge). Despite some differences in inefficiency scores, the rankings of units do not differ between the methods. The rank correlations of the inefficiency scores are over 0.99 in each year between the different distributional assumptions.

Figure 5 *Spread and median of the inefficiency scores with three different distributional assumptions for years 1998–2004*[18]



The test used to compare the half normal and truncated normal models (H_0: $\mu=0$), suggests to accept the null hypothesis for all the estimated years. This result gives support to the frontier estimation with half-normal distribution. Because of this, and the fact that the estimated parameters varied only very slightly between the different distributional assumptions, we report in the following only the

[17] The reported scores indicate the amount of inefficiency in percentage terms.

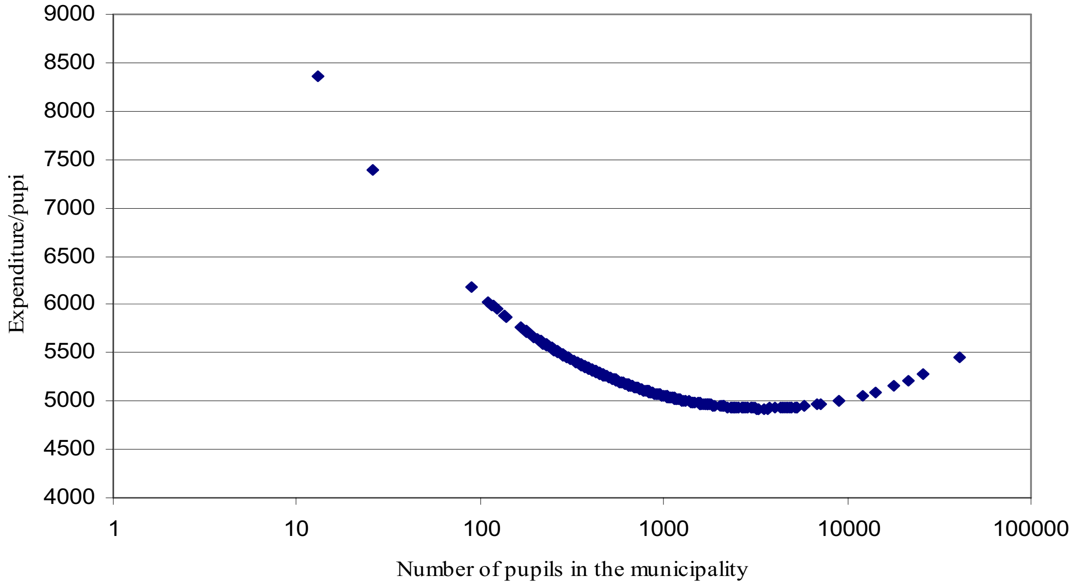
[18] The results are also summarised in Appendix, Table 15.

parameter estimates from estimations based on half-normal distribution (Table 5).

When testing for heteroscedasticity, we find that both the idiosyncratic error term v_i and the cost inefficiency term u_i are heteroscedastic and that heteroscedasticity in v_i and u_i is linked with the number of pupils. However, we also find that correcting for heteroscedasticity leads to only slightly different technical inefficiency scores for most years (see Figure 12 in Appendix). In other words, it seems that in our case the bias in v_i and u_i, that is in opposite directions, result in small overall bias. Also, the parameter estimates from cross-section frontier estimations produce very similar result in heteroscedasticity corrected and non-corrected models. Therefore, we choose to report the non-corrected estimation results.

As for the results of the parameter estimates of the explanatory variables (Table 5), we find that, as expected, the *average salary* affects the expenditures positively. The effect of size of the pupil population is measured with the *number of pupils* and the effect of municipal size is measured with *number of inhabitants in municipality* (not reported in Table 5). We find that the scale effect, measured with these variables, is statistically significant and non-linear. For example, as the number of pupils in the municipality increases, the per pupil expenditures decrease up to a minimum and then start to increase again. In year 2004 the minimum is reached at 3 260 pupils. In the same way, when the municipal population was used as explanatory variable, the per pupil expenditures decreased up to 24000–37 000 inhabitants.

Figure 6 *The estimated expenditures and the average size of the municipality in 2004 (log scale of number of pupils)*



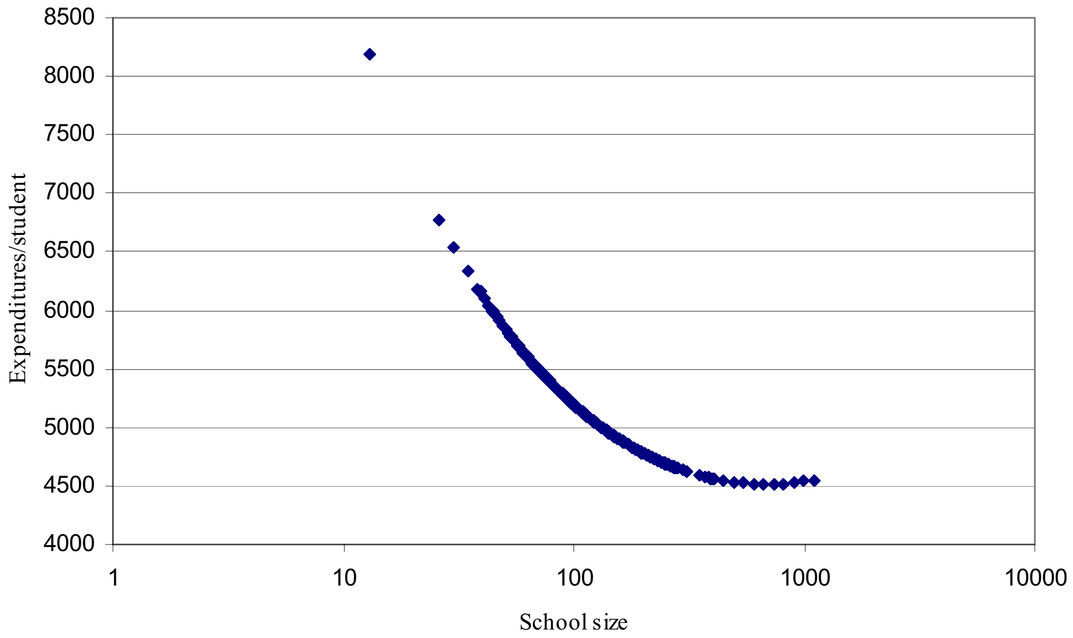
The two variables measuring the quality of output, the *grade point average* and the percentage share of pupils who get *admitted to upper secondary and vocational schooling* do not seem to have statistically significant effect on expenditures.

The *municipal tax base* has a positive effect on expenditures. It seems, in other words, that the wealth of the municipality increases spending in comprehensive schooling.

As expected, the share of *pupils using transportation* had a positive effect on expenditures. The *share of pupils in 1.–6. grades* and per pupil expenditures are negatively connected. For example we can see from Table 5 that, all other things equal, ten percentage point increase in the share of pupils in 1.–6. grades decreases costs by 3 - 5 percent. A*ccommodation* and the share of *non-Finnish-speaking pupils* had a positive effect on expenditures and the share of pupils at the *remedial instruction* affected the expenditures positively, but only in 2002 and 2003.

Average school size has a strong and consistent negative effect on expenditures. In other words, there seem to be positive scale effects involved with larger schools. The estimated optimum school size was 692 pupils in 2004. Most Finnish schools are much smaller than this as the average school size in Finland was 160 pupils in 2004.

Figure 7 *The estimated expenditures and the average school size in municipality in 2004*



In most of the years the share of the *socialist representatives in the council* did not affect expenditures. The coefficient is statistically significant only in 1998. The *coastal location* increased expenditures in 1998 and 1999. In most of the years (not in 1999) there were no differences in expenditures between municipalities which maintain and which do not maintain *upper secondary schools.*

Table 5 The determinants of SFA-efficiency differences in cross-section models in 1998–2004[19]

	1998	1999	2000	2001	2002	2003	2004
Average salary	0.304	0.234	0.340	0.283	0.347	0.280	0.204
	(4.79)**	(3.59)**	(4.96)**	(4.04)**	(5.43)**	(4.39)**	(2.91)**
Grade point average	0.027	0.020	-0.003	0.018	-0.010	-0.005	-0.011
	(0.91)	(0.71)	(0.12)	(0.79)	(0.40)	(0.19)	(0.47)
% Upper secondary schooling	0.058	0.080	0.069	0.090	0.175	0.018	0.190
	(0.65)	(0.89)	(0.64)	(0.85)	(1.47)	(0.14)	(1.59)
No. of pupils	-0.230	-0.279	-0.252	-0.297	-0.348	-0.239	-0.277
	(3.66)**	(4.90)**	(4.33)**	(5.97)**	(7.46)**	(4.71)**	(5.48)**
Square no. of pupils	0.016	0.019	0.018	0.019	0.022	0.015	0.017
	(3.83)**	(5.02)**	(4.57)**	(5.76)**	(6.97)**	(4.51)**	(5.02)**
% in remedial instruction	0.192	0.365	0.041	0.407	0.667	0.697	0.347
	(0.54)	(1.18)	(0.15)	(1.56)	(2.91)**	(3.28)**	(1.48)
% Pupils transported	0.172	0.169	0.170	0.204	0.157	0.141	0.167
	(4.23)**	(4.24)**	(4.35)**	(5.13)**	(4.01)**	(3.83)**	(4.10)**
% Pupils in 1.–6. grade	-0.433	-0.350	-0.549	-0.344	-0.295	-0.308	-0.301
	(4.69)**	(3.74)**	(6.68)**	(3.74)**	(3.10)**	(3.24)**	(3.14)**
% Non-Finnish -speaking pupils	0.104	0.077	0.081	0.071	0.105	0.074	0.061
	(4.36)**	(3.42)**	(3.23)**	(2.94)**	(4.50)**	(3.13)**	(2.53)*
Taxable income/inhabitant	0.148	0.123	0.142	0.195	0.104	0.118	0.107
	(3.26)**	(2.97)**	(3.33)**	(4.25)**	(2.30)*	(2.48)*	(2.29)*
Average school size	-1.056	-1.042	-0.770	-0.836	-0.664	-0.494	-0.496
	(6.80)**	(7.35)**	(5.27)**	(5.96)**	(4.97)**	(3.50)**	(3.35)**
Square average school size	0.087	0.088	0.058	0.068	0.052	0.036	0.038
	(5.25)**	(5.85)**	(3.76)**	(4.56)**	(3.72)**	(2.42)*	(2.48)*
Education index	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000
	(1.16)	(1.31)	(1.70)	(1.84)	(0.16)	(1.92)	(0.97)
% Socialists in the council	0.111	0.066	0.053	0.066	0.072	0.044	0.013
	(2.74)**	(1.78)	(1.38)	(1.80)	(1.94)	(1.25)	(0.33)
Costal area	0.022	0.033	0.010	0.011	-0.002	-0.001	0.011
	(2.12)*	(3.00)**	(0.89)	(0.99)	(0.14)	(0.06)	(1.04)
Upper secondary school (dummy)	0.025	0.033	0.006	0.019	0.019	0.008	0.017
	(1.95)	(2.72)**	(0.44)	(1.61)	(1.57)	(0.65)	(1.42)
lnsig2v:Constant	-6.566	-6.705	-6.392	-6.295	-6.324	-6.722	-6.005
	(18.41)**	(17.80)**	(22.55)**	(25.13)**	(28.37)**	(22.61)**	(28.50)**
lnsig2u:Constant	-4.361	-4.331	-4.401	-4.542	-4.464	-4.299	-4.602
	(25.30)**	(26.50)**	(26.76)**	(26.28)**	(30.08)**	(31.68)**	(24.63)**
Constant	8.333	9.237	7.913	7.909	8.055	7.856	8.566
	(11.32)**	(12.94)**	(10.25)**	(10.08)**	(10.99)**	(10.50)**	(10.51)**

Absolute value of z statistics in parentheses
* significant at 5%; ** significant at 1%

[19] All explanatory variables in logarithmic form except ratios, pupils/teaching stuff and education index. The municipality specific inefficiency figures can be found in Appendix, Table 19.

Table 6 Test results for the SFA-estimations

	1998	1999	2000	2001	2002	2003	2004
Observations	360	360	362	359	360	359	360
Wald –test	chi2(16)= 1023.97 Prob >chi2= 0.000	chi2(16)= 1091.46 Prob >chi2= 0.000	chi2(16)= 1286.14 Prob >chi2= 0.000	chi2(16)= 1314.74 Prob >chi2= 0.000	chi2(16)= 1267.22 Prob >chi2= 0.000	chi2(16)= 1398.82 Prob >chi2= 0.000	chi2(16)= 1113.07 Prob >chi2= 0.000
Likelihood-ratio -test	Prob >chibar2= 0.000	Prob >chibar2= 0.000	Prob >chibar2= 0.000	Prob >chibar2= 0.000	Prob >chibar2= 0.000	Prob >chibar2= 0.000	Prob >chibar2= 0.000

7.2 Panel data frontier estimations

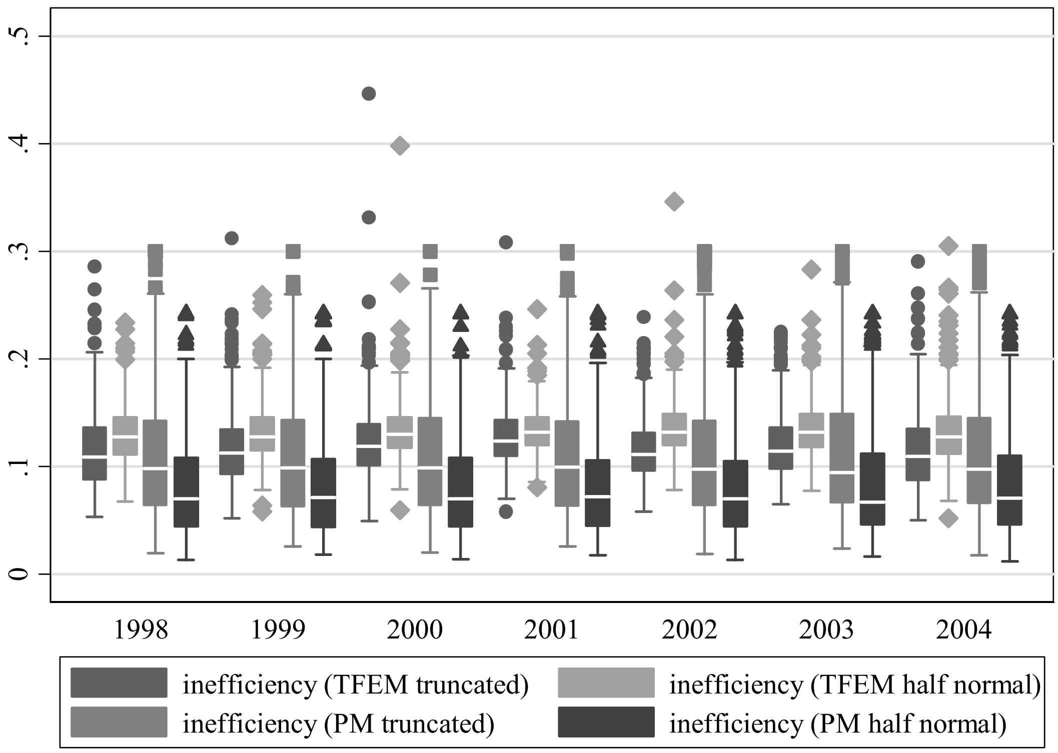
According to the results, the true fixed effects[20] method produces somewhat higher average inefficiency scores than the pooled frontier estimation (Figure 8). The estimated overall (over the period) inefficiency using true fixed effects estimation is between 11.9 percent (truncated-normal distribution) and 13.3 percent (half-normal distribution). In comparison, the average inefficiency scores for pooled panel data estimations are 11.2 percent (truncated-normal) and 8.3 (half-normal).[21] We tested the time constancy of inefficiency parameters, finding that the inefficiency effects decrease over time (see also Table 17 in the Appendix). The variance of the scores are slightly diminishing towards the end the period, too.

Rank correlation tests show that the ranking of units is rather different between the true fixed effects and pooled panel data models, since rank correlation is only 0.44. One reason for this is that the true fixed effect -models are calculated by using only information which varies over time. On the other hand, in the pooled panel model we use only information of the variance that comes from between the municipalities and we do not control for heterogeneity. The pooled panel model measures only how much every municipality has produced services compared to the used resources in every year.

[20] Due to estimation problems that led to no convergence of some of the models, we present here the true fixed effects and simple pooled panel data results only. Limdep 8.0 was used to estimate the true fixed effects models.

[21] Summary statistics of inefficiency scores are also reported in Table 16 in Appendix.

*Figure 8 Inefficiency scores from panel frontier estimations**



* TFEM (True fixed effects model), PM (frontier estimation on pooled panel)

The panel estimations produce fairly similar results for the parameter estimates compared to the cross-section estimation results (Table 7).[22] Some of the variables that were not statistically significant in cross-section regression, are now significant. These variables include the *percent of pupils continuing their studies at the upper secondary and vocational schooling*, *percentage of pupils in remedial instruction* and the *education level* of the municipal population.

As the average inefficiency has been stable over the whole period analysed, the technical change can be taken as a rough estimate of productivity development. In Table 7 the year dummies reflect the inverse of technical change. Using this result, shown in Table 7, the productivity of the municipalities declined on average 12 percent between years 1998–2004, which is in line with the results presented in Chapter 6.2.2.[23]

[22] We choose to report the results from true fixed effects estimation with truncated normal distribution assumption. The main reason for this is that compared to all other models, the estimation results with half normal distribution produced very different parameter estimates.

[23] When the average inefficiency is stable over the period, the productivity development is the same as the technical change. In this case the inverse of the year dummies in Table 7 reflect the technical change of the Finnish comprehensive school system. If we had used costs without the social insurance fees, pension

Table 7 The results for true fixed effects and pooled panel data estimations

	True fixed effects (truncated normal distribution)	**Pooled panel data** (truncated normal distribution)
Average salary	0.284	0.274
	(15.62)**	(11.90)**
Grade point average	0.000	0.000
	(0.057)	(0.026)
% To upper secondary schooling	0.115	0.108
	(3.83)**	(2.83)**
No. of pupils	-0.311	-0.312
	(18.91)**	(15.84)**
Square no. of pupils	0.020	0.020
	(18.54)**	(15.36)**
% in remedial instruction	0.442	0.43
	(5.88)**	(4.30)**
% Pupils transported	0.172	0.162
	(13.61)**	(9.95)**
% Pupils in 1.–6. grade	-0.323	-0.323
	(11.01)**	(8.81)**
% Non-Finnish -speaking pupils	0.100	0.089
	(13.86)**	(9.89)**
Taxable income/inhabitant	0.147	0.140
	(11.69)**	(8.29)**
Average school size	-0.821	-0.808
	(23.05)**	(15.97)**
Square average school size	0.067	0.066
	(17.35)**	(12.23)**
Education index	0.000	0.000
	(5.10)**	(4.20)**
% Socialists in the council	0.055	0.052
	(4.85)**	(3.67)**
Coastal area	-	0.017
	-	(4.41)**
Upper secondary school (dummy)	0.020	0.022
	(5.39)**	(4.65)**
Constant	-	8.569
	-	(32.44)**
Observations (N of municipalities)	2492 (357)	2492 (357)
Lambda	6.972	12.297
	(17.63)**	-0.28
Sigma	0.347	0.629
	(68.87)**	-0.27
Log likelihood	1857.29	2912.26
Sigma (u), [Sigma (v)]	0.343, [0.049]	0.62682, [0.05097]

* significant at 5%; ** significant at 1%

insurance fees and paid pensions, the productivity decline would have been a bit smaller, approximately 9 percent.

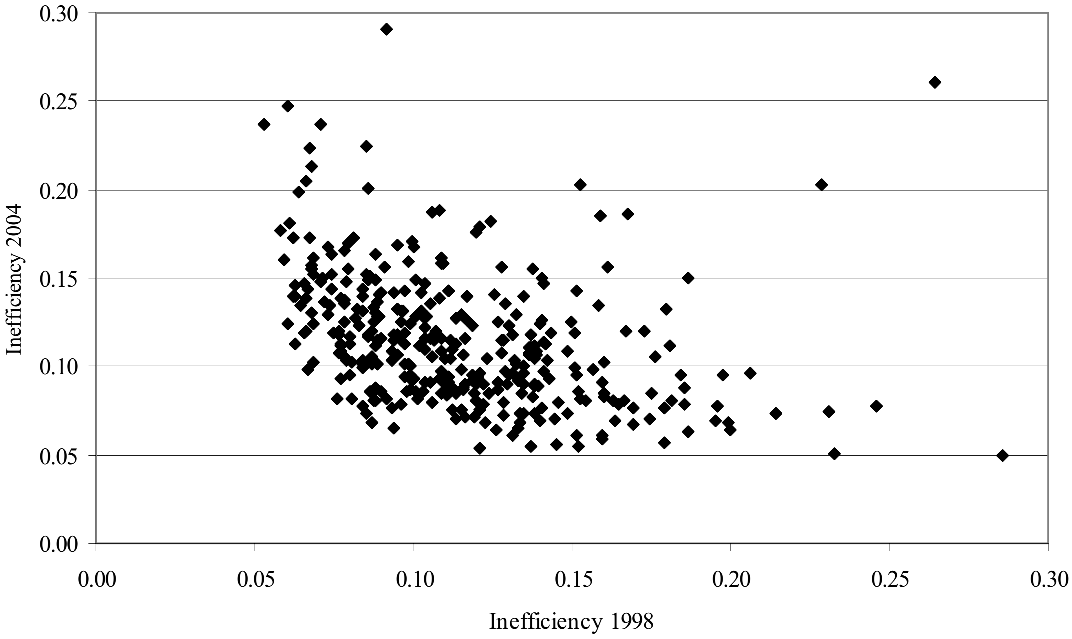
Table 7 Continued: the dummy variable results for true fixed effects and pooled panel data estimations

	True fixed effects	**Pooled panel data**
Dummy for year 1999	0.025	0.026
	(6.68)**	(4.76)**
Dummy for year 2000	0.051	0.052
	(12.56)**	(9.46)**
Dummy for year 2001	0.078	0.079
	(17.56)**	(13.77)**
Dummy for year 2002	0.083	0.084
	(17.99)**	(14.14)**
Dummy for year 2003	0.106	0.108
	(21.99)**	(16.99)**
Dummy for year 2004	0.120	0.122
	(24.49)**	(19.12)**

In Figure 9 we examine how the inefficiency scores of the true fixed effect - model change from 1998 to 2004. We can see that inefficiency scores are negatively correlated[24]. It seems that for quite a few municipalities with low inefficiency in year 1998 had a clearly higher inefficiency in 2004. Similarly, many municipalities with high inefficiency in 1998 have improved their position in 2004.

[24] We also tested for rank correlation finding rank correlation of -0.48.

Figure 9 *Inefficiency scores from the true fixed effect model*



7.3 The comparison of inefficiency scores from production and cost function models

Comparing the DEA efficiency scores and SFA cost inefficiency scores is not straightforward for many reasons. The most obvious problem is that DEA calculation does not control for the differences in the operational environment and the pupil structure of the municipalities, whereas SFA includes these variables directly in the estimation. Comparison of the rankings from these two methods may then give biased view of the situation. Therefore, we need to explain the DEA efficiency scores as a second step using environmental and student characteristics before any meaningful comparison is possible. Further, it is by no means clear whether one can compare the results from production function and cost function directly in any case. Kumbhakar and Lovell (2000, 131-133) discuss the problems of comparison in more detail.

In this section, we compare the results from the so called two stage DEA and SFA in a very general manner. We start by noting that the results from both methods suggest stable differences between units over the period analysed. The standard deviation has been nearly constant using both methods (Table 8). In addition, the average SFA -inefficiencies show a slight decrease and the DEA -efficiencies slight increase from 1998 to 2004. In other words, we find a modest positive development with both methods.

The results from both methods suggest a degree of efficiency potential below 10 percentage points.[25] However, one must note here that the efficiency differences have been quite large. From SFA-analysis we see that the least efficient municipalities have been approximately 40 % and in year 2003 almost 50 % less efficient than the most efficient municipalities. The differences measured with DEA are even higher.

There is high rank correlation (-0,88 for year 2004) between the DEA-residual (efficiency measured with DEA minus the efficiency predicted by the explanatory model) and the SFA inefficiencies (Figure 10) for all the years analysed.[26] Hence, in sum, we conclude that there are only small differences between the results from the two methods, especially when it comes to approximate efficiency potentials and ranking of the units.

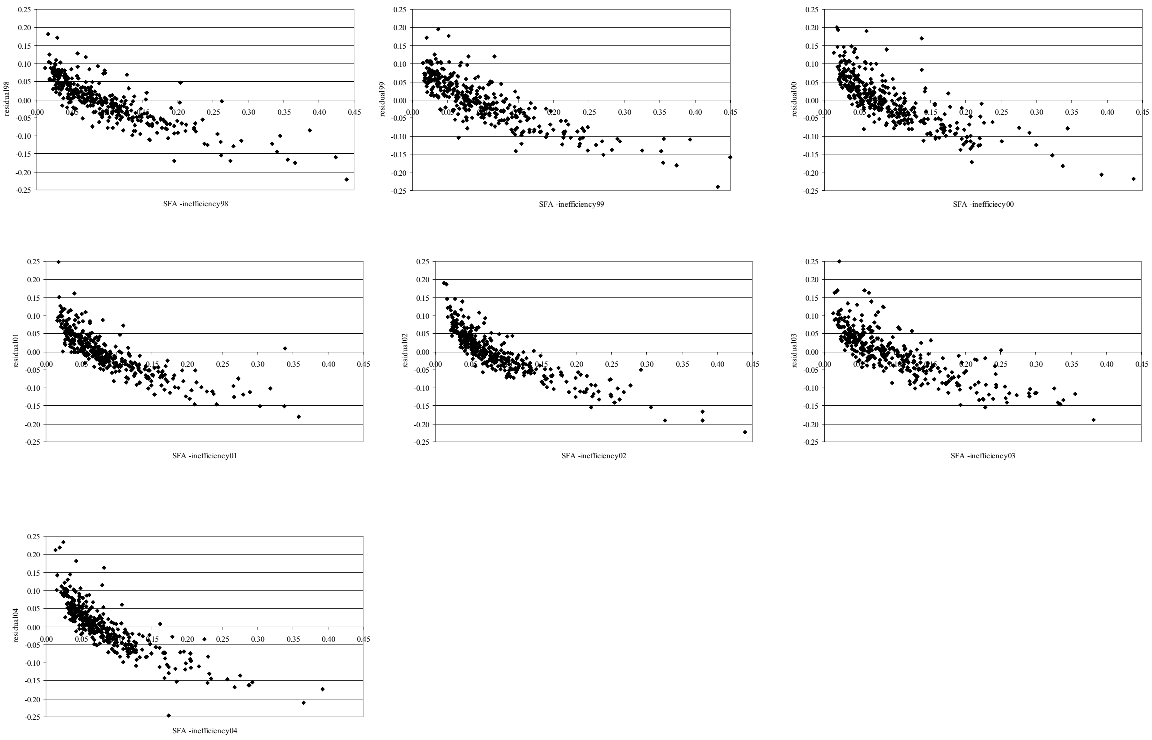
Table 8 SFA-inefficiency and DEA-efficiency scores of comprehensive schooling in 1998–2004

	1998	1999	2000	2001	2002	2003	2004
SFA:							
Average inefficiency	0.10	0.10	0.09	0.09	0.09	0.10	0.08
Min	0.01	0.01	0.01	0.02	0.01	0.01	0.01
Max	0.44	0.45	0.45	0.36	0.44	0.48	0.39
Std. Deviation	0.07	0.07	0.07	0.06	0.07	0.07	0.06
DEA (CRS model):							
Average efficiency	0.75	0.75	0.78	0.78	0.79	0.79	0.79
Min	0.32	0.38	0.38	0.42	0.39	0.41	0.37
Max	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Std. Deviation	0.11	0.11	0.11	0.10	0.11	0.10	0.11
Pseudo R^2 (Tobit estimation)	-0.90	-0.77	-0.71	-0.76	-0.72	-0.52	-0.57

[25] From table 8 we can see that the DEA -gaps between the average efficiency and maximum varied between 19 and 25 percent. Depending on the explanatory power of environmental and other factors on DEA-efficiency differences, the remaining unexplained inefficiency can be approximated to vary between 3 and 10 percentage points. In case of SFA, the inefficiency difference between the best and the mean unit varies between 7 and 9 percentage points, depending of the year.

[26] The bigger value of SFA-efficiency means less efficient unit and the positive value of DEA-residual means that the unit is more efficient than is expected by the explanatory model.

Figure 10 SFA- efficiency score and DEA-residual[27] in 1998–2004



[27] Residual = DEA-efficiency score – predicted efficiency score

8. PISA test scores and efficiency[28]

We also estimated an education production frontier model at the municipal level using the information on OECD PISA -test results for Finnish schools as our output measure for years 2000 and 2003. PISA covers the range of skills and competencies that are considered to be crucial to an individual's capacity to fully participate in, and contribute meaningfully to a successful modern society. In that sense the tests are meant to assess how well pupils are prepared to meet real-life challenges at the end of the compulsory education. PISA is administered to 15-year-olds (9th grade pupils in Finland). In year 2000 the PISA consisted of three different subjects: mathematical literacy, reading literacy and scientific literacy. In year 2003 there was also problem solving literacy in addition to the above mentioned.

Using these test results as outputs in separate models we estimate an SFA production function of the form:

$$\ln y_i = \beta_0 + \sum_{j=1}^{k} \beta_j \ln x_{ji} + v_i - u_i \ ,$$

where $\ln y_i$ is the log of the output, which is the average test score of the pupils that took part in the test in the schools in municipality i, β's are parameters to be estimated, $\ln x_{ij}$ are the explanatory variables, v_i is the idiosyncratic error term and u_i are the inefficiency terms[29]. As the statistical tests supported the assumption of half-normally distributed inefficiency terms, we use this assumption in the estimations.

The model we use in the frontier estimations differs somewhat from the previous ones we have used in second stage DEA and cost function SFA.[30] Our input variables were the *ratio of pupils to teachers*, *the proportion of teachers with university degree*, the *proportion of full-time teachers*, and *school size*. Family background of the pupils was measured by Highest International Socio-economic Index of Occupational Status, where the higher value of pupil's mother or father was selected and summed up into municipal level. Pupil characteristics is measured with the *proportion of Non-Finnish -speaking pupils*, the *proportion of pupils receiving remedial instruction* in the 9th grade and the *share of females* in the 9th grade. All variables are logged before estimations except the ones that are

[28] We thank professor Jouni Välijärvi and Dr. Antero Malin from the Institute for Educational Research in University of Jyväskylä for the data set used in the analysis.

[29] Note that the production function efficiency scores are between 0-1, where 1 is the maximum. So these figures are inverse compared to cost function scores reported in previous chapter.

[30] Summary statistics of the variables used can be found in Appendix, Table 12.

in ratio form. The estimation results for year 2003 are reported in table 9 and for year 2000 the results are reported in Appendix (Table 18).

As for the input variables, *the pupil/teacher ratio* does not seem to affect the achievement. Neither does the *proportion of teachers who have a university degree*. This result may partly be due to the small variation in the variable since in most of the subjects to be a qualified teacher, a university degree is required. Surprisingly, *share of full time teachers* affected negatively on math achievement but was statistically insignificant in other subjects. We found some evidence that *school size* affects positively on mathematical literacy results but we did not find this effect for other subjects[31].

As for the pupils' background factors, in accordance with other studies *parents' occupational status* affects learning positively. An increase of 10 percent in parents' occupational status increases PISA scores approximately one percent. As expected the *proportion of non Finnish –speaking pupils* affected negatively on learning. A ten percent increase in the share of *non Finnish-speaking pupils* decreased the test results by 0.4–0.7 percent. The *share of female pupils* in 9th grade did not affect test results and neither did the *proportion of pupils in remedial instruction*.

[31] Neither could we find nonlinear connection between school size and pupil learning.

Table 9 The estimation results for year 2003 using PISA-data

	reading literacy	mathematical literacy	scientific literacy	problem solving	all
Pupil-teacher ratio	-0.003	-0.004	-0.003	-0.004	-0.004
	(1.29)	(1.77)	(1.14)	(1.68)	(1.49)
Parents' occupational status	0.088	0.107	0.107	0.113	0.105
	(3.44)**	(3.94)**	(3.65)**	(4.30)**	(4.01)**
% Share of teachers with university degree	-0.011	0.009	0.001	0.002	0.001
	(0.80)	(0.68)	(0.06)	(0.17)	(0.07)
% Full time teachers	0.002	-0.046	-0.029	-0.033	-0.028
	(0.09)	(2.09)*	(1.21)	(1.52)	(1.31)
School size	0.005	0.019	0.013	0.012	0.012
	(0.63)	(2.04)*	(1.29)	(1.42)	(1.40)
% Non-Finnish-speaking pupils	-0.044	-0.046	-0.071	-0.057	-0.055
	(5.36)**	(5.50)**	(7.85)**	(6.66)**	(6.70)**
% female	0.043	0.029	0.042	0.046	0.04
	(0.83)	(0.51)	(0.69)	(0.78)	(0.73)
% in remedial instruction	-0.002	-0.009	-0.019	0.001	-0.006
	(0.05)	(0.23)	(0.46)	(0.02)	(0.16)
lnsig2v:Constant	-8.164	-7.624	-7.291	-8.012	-7.846
	(20.99)**	(17.57)**	(16.89)**	(17.03)**	(19.69)**
lnsig2u:Constant	-6.394	-6.801	-7.095	-6.414	-6.67
	(23.34)**	(11.64)**	(7.14)**	(18.11)**	(16.24)**
Constant	5.975	5.867	5.879	5.875	5.896
	(64.58)**	(58.75)**	(54.48)**	(61.22)**	(61.75)**
Observations	112	112	112	112	112

Absolute value of z statistics in parentheses; * significant at 5%; ** significant at 1%

We find only small efficiency differences between municipalities when learning results are used as an output. The average efficiency scores were mostly 0.97 or higher, which means that on average the inefficiency was less than three percent. For 2000, we found no inefficiency. That was also the case for 2003 when using mathematical literacy and scientific literacy as an output. Overall, it seems that it does not matter for inefficiency whether we use total score or scores in single subjects as an output.

Table 10 Summary of efficiency scores

Output	Mean	Std. Dev.	Min	Max
Reading literacy 2000	0.978	0.008	0.943	0.990
Mathematical literacy 2000	0.976	0.010	0.931	0.992
Scientific literacy 2000	0.969	0.015	0.899	0.989
All 2000	0.976	0.010	0.925	0.991
Reading literacy 2003	0.969	0.020	0.865	0.994
Mathematical literacy 2003	0.974	0.014	0.921	0.991
Scientific literacy 2003	0.977	0.010	0.947	0.992
Problem solving 2003	0.969	0.019	0.897	0.993
All 2003	0.972	0.016	0.909	0.993

9. Summary

In this paper we examined the efficiency differences and productivity of Finnish comprehensive schooling during 1998–2004. We estimated both production and cost functions. Production functions were estimated with DEA and second stage explanatory model and cost functions with Stochastic frontier analysis (SFA).

Using DEA, we found that the average efficiency varied between 75 and 81 percent during 1998–2004. However, according to our statistical models explaining the efficiency, about two thirds of the differences were due to environmental variables and pupil characteristics that are not directly under the influence of schools and municipalities. That left us with approximately 6–10 percent average inefficiency. The results also show strong relationship between school size and efficiency so that increasing school size increases efficiency. Furthermore, we found that the municipal wealth measured with taxable incomes has a negative effect on efficiency. This result is due to the fact that in the wealthy municipalities the expenditures are higher than in the average municipality.

The cost function analysis with SFA produced similar results to two-stage DEA. The average inefficiency varied between 8 and 10 percent. Therefore, the results presented in this paper are robust to different methods and various model specifications. According to cost function estimations the shares of non-Finnish - speaking pupils and pupils transported have positive effect on costs whereas share of pupils in 1.-6. grade decreased the costs. As for the optimal municipal size measured with population, we find that costs decrease up to 24 000–37 000 inhabitants and thereafter they start to increase.

We calculated productivity changes based on panel data, controlling for the environment and pupil characteristics. According to results, the productivity of comprehensive schools decreased on average 12 percent during 1998–2004. This is a dramatic change, even though part of it can be explained by the teacher pension system change that the deflators available do not completely take into account. In addition, we could not control for possible quality improvements. The increase in per capita taxable income and the share of students in remedial instruction had the biggest impact on productivity decrease. Larger school size had a clear positive effect on productivity.

We also estimated education production frontier models using the information on OECD PISA -test scores for Finnish schools as output measure for 2000 and 2003. According to results, the efficiency differences between municipalities are very small, especially compared to the results obtained with other models in this paper. The inefficiency found was on average less than three percent. Not surprisingly, the results show that parents' occupational status had a positive and the proportion of non Finnish -speaking pupils a negative effect on test scores.

References

Aaltonen, J. - Räty, T. - Järviö, M-L. - Luoma, K. (2005): Perusterveydenhuollon Kustannukset ja Tuotetut Palvelut – Tuottavuuden Kehitys 1997–2003. Valtion taloudellinen tutkimuskeskus. Keskustelualoitteita 372. Helsinki.

Aaltonen, J. - Järviö, M-L. - Luoma, K. - Räty, T. (2004): Terveyskeskusten tuottavuuden ja tehokkuuserojen kehitys vuosina 1988–2002. Valtion taloudellinen tutkimuskeskus. Keskustelualoitteita 354. Helsinki.

Aigner, Lovell and Schmidt (1977): Formulation and estimation of stochastic frontier production function models. *Journal of Econometrics* **6**, 21-37.

Barrow, M. M. (1991) Measuring Local Education Authority Performance: A Frontier Approach. *Economics of Education Review* **10**, 19-27.

Battese, G. - Coelli, T. (1992): Frontier production functions, technical efficiency and panel data: with application to paddy farmers in India. *Journal of Productivity Analysis*, 3 (1), 153-169.

Battese, G. - Coelli, T. (1995): A model for technical efficiency effects in a stochastic frontier production function for panel data. *Empirical economics*, 20, 325-332.

Bessent, A. - Bessent, W. (1980): Determining the Comparative Efficiency of Schools through Data Envelopment Analysis. *Educational Administration Quarterly* **16**, 57-75.

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

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

Bradley, S. - Johnes, G. - Millington, J. (2001): The Effect of Competition on the Efficiency of Secondary Schools in England. *European Journal of Operational Research* **135**, 545-568.

Charnes, A. - Cooper, W.W. - Lewin, A. Y. - Seiford, L.M. (eds.) (1995): Data Envelopment Analyses: Theory, Methodology and Applications. Kluwer Academic Publishers. Boston.

Charnes, A. - Cooper, W.W. – Rhodes, E. (1978): Measuring the Efficiency of Decision Making Units. *Management Science* **27**, 668-697.

Coelli, T. (1995): Estimators and hypothesis tests for a stochastic frontier function: A Monte Carlo analysis. *Journal of Productivity Analysis*. Vol. 6, No. 3, 247-268.

Coelli, T. - Rao, P.D.S. - Battese, G.E. (1999): An Introduction to Efficiency and Productivity Analyses. Kluwer Academic Publishers. Boston.

Coleman, J. *et al*. (1966): *Equality of Educational Opportunity*. Washington: U.S. Government Printing Office.

Cooper, S. T. - Cohn, E. (1997): Estimation of a Frontier Production Function for the South Carolina Educational Process. *Economics of Education Review* **16**, 313-327.

Cooper, W. - Seiford, L. - Tone, K. (2000): Data Envelopment Analysis. A Comprehensive Text with Models, Applications, References and DEA-Solver Software. Kluwer Academic Publishers.

Deller, S. C. - Rudnicki, E. (1993) Production Efficiency in Elementary Education: The Case of Maine Public Schools. *Economics of Education Review* **12**, 45-57.

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

Duncombe, W. - Miner, J. - Ruggiero, J (1995) Potential Cost Savings from School District Consolidation: A Case Study of New York. *Economics of Education Review* **14**, 265-284.

Farrell, M. (1957): The Measurement of Productive Efficiency. *Journal of the Royal Statistical Society* **A 120**, 253-281.

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

Greene, W. (2005a): Fixed and Random Effects in Stochastic Frontier Models. *Journal of Productivity Analysis*, **23**, 7-32.

Greene, W. (2005b): reconsidering heterogeneity in panel data estimators of the stochastic frontier model. *Journal of Econometrics*, **126**, 269-303.

Hanushek, E. A. (2003): The Failure of Input-Based Schooling Policies. *The Economic Journal* **113**, F64-F98.

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

Hedges L. - Greenwald, R. (1996): Have Times Changed? The Relation between School Resources and Pupil Performance. In Burtless G. (ed.) Does Money

Matter? The Effect of School Resources on Pupil Achievement and Adult Success. Washington DC: Brookings Institution Press.

Heshmati, A. - Kumbhakar, S. C. (1997): Efficiency of the Primary and Secondary Schools in Sweden. *Scandinavian Journal of Educational Research* **41**, 33-52.

Jesson, D. - Mayston, D. - Smith, P. (1987): Performance Assessment in the Education Sector: Educational and Economic Perspectives. *Oxford Review of Education* **13**, 249-266.

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

Kirjavainen, T. - Loikkanen, H. A. (1993): Lukioiden tehokkuuseroista. *VATT-tutkimuksia* no. 16. Helsinki: Valtion taloudellinen tutkimuskeskus.

Krueger, A. (2003): Economic Considerations and Class Size. *The Economic Journal* 113, F34-F63.

Kumbhakar and Lovell (2000): Stochastic Frontier Analysis. Cambridge University Press.

Kumbhakar and Wang (2006): Pitfalls in the estimation of a cost function that ignores allocative inefficiency: A Monte Carlo analysis. *Journal of Econometrics* **134**, 317-340.

Ludwin, W. - Guthrie, T. (1989): Assessing Productivity with Data Envelopment Analysis. *Public Productivity Review* **12**, 361-372.

McCarty, T. A. - Yaisawarng, S. (1993): Technical Efficiency in New Jersey School Districts, in Fried *et al.* (eds.) *The Measurement of Productive Efficiency. Techniques and Applications.* New York: Oxford University Press.

Meeusen, W., Broeck, van der J. (1977): Technical efficiency and dimension of the firm: some results on the use of frontier production functions. Empirical Economics **2**, 109-122.

Mizala, A. - Romaguera, P. - Farren, D. (2002): The Technical Efficiency of Schools in Chile. *Applied Economics* **34**, 1533-1552.

Moisio, A. (2002): Essays on Finnish municipal finance and intergovernmental grants, Doctoral thesis, Government Institute for Economic Research (VATT) Research reports 93.

Ruggiero, J. (1996): Efficiency of Educational Production: An Analysis of New York School Districts. *The Review of Economics and Statistics* **78**, 499-509.

STATA 8.0 Manual (2003), p. 65-73. Stata Corporation.

Smith, P. - Mayston, D. (1987): Measuring Efficiency in the Public Sector. *OMEGA International Journal of Management Science* **15**, 181-189.

Wooldridge, J. M. (2002): *Econometric Analysis of Cross Section and Panel Data.* The MIT Press.

Appendix

Table 11 Mean values for the input and output variables in DEA in 1998–2004

	1998	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**
Teaching costs	4740	4897	4990	5103	5180	5267	5297
Other costs	2309	2363	2369	2465	2482	2592	2596
Number of pupils completing grades 1.-6.	998	1000	1010	1028	1029	1033	1018
Number of pupils completing grades 7.-8.	354	344	330	323	328	337	342
Number of pupil continuing their studies	161	160	157	151	147	146	149
Number of pupils completing comprehensive school*							
Grade point Average of school leaving sertificate	1414	1407	1376	1331	1275	1263	1331

Table 12 Mean (municipal level) values for the PISA-data variables

	2000	2003
Reading literacy (avg. score in points)	547	540
Mathematical literacy (avg. score in points)	538	540
Scientific literacy (avg. score in points)	538	542
Problem solving (avg. score in points)	-	543
All (avg. score in points)	541	541
Pupil-teacher ratio	0.104	0.111
Parents' occupational status	48.2	48.0
% Share of teachers with university degree	0.892	0.837
% Full time teachers	0.812	0.846
School size	351	327
% Non-Finnish-speaking pupils	0.048	0.199
% female	0.497	0.500
% in remedial instruction	0.031	0.092

Input and output weights used in DEA -models

We have used weight restrictions for the output variables in DEA. First, we set restriction that a pupil in lower level of comprehensive school is at minimum 0.75 times and at maximum 1.1 times compared to pupil in the upper level of comprehensive school.[32] This means that on average a pupil in classes 7–9 is more valuable than a pupil in classes 1–6.

Second, we assume that a pupil admitted to upper secondary schooling is at least as valuable as upper grade pupil. Third, we assume that the value of pupil admitted to secondary schooling is at the minimum 10 times and at the maximum 20-times the value of grade point average at the comprehensive school certificate.[33] Fourth, we assume that teaching expenditure is as valuable as other expenditure.

Figure 11 The weight restrictions used in the DEA analysis

(1) $$0{,}75 \le \frac{\text{1.-6. grade pupil}}{\text{7.-8. grade pupil}} \le 1.1$$

(2) $$1 \le \frac{\text{Student admitted to upper secondary schooling}}{\text{7.-8. grade pupil}}$$

(3) $$10 \le \frac{\text{Pupil admitted to upper secondary schooling}}{\text{Grade point average of comprehensive school certificate}} \le 20$$

(4) $$\frac{\text{Teaching expenditures}}{\text{Other expenditure}} = 1$$

[32] This restriction is based on the regression result where we found that a ten percent increase in the share of lower level of comprehensive school pupils increases the expenditures by 3-5 percent.

[33] The grade point average of the pupils completing their studies at the comprehensive school has been on average little below eight.

Table 13 The description of the variables used in the analysis

Variable		Mean	Std. Dev	Min	Max			Observations
DEA inefficiency	overall	0.72051	0.104	0.319	1.000	N	=	2520
	between		0.097	0.374	0.924	n	=	368
	within		0.043	0.553	0.920	T-bar	=	6.8478
Average salary	overall	7.85074	0.063	7.505	8.122	N	=	2520
	between		0.055	7.658	8.064	n	=	368
	within		0.033	7.541	7.991	T-bar	=	6.8478
Grade point average	overall	7.75266	0.164	6.267	8.545	N	=	2520
	between		0.116	7.469	8.217	n	=	368
	within		0.117	6.539	8.576	T-bar	=	6.8478
% Upper secondary schooling	overall	0.95168	0.044	0.705	1.000	N	=	2520
	between		0.032	0.773	1.000	n	=	368
	within		0.030	0.768	1.051	T-bar	=	6.8478
No. of pupils	overall	6.72547	0.963	2.565	10.619	N	=	2520
	between		0.993	2.620	10.598	n	=	368
	within		0.067	6.437	7.352	T-bar	=	6.8478
Square no. of pupils	overall	46.1588	13.644	6.579	112.757	N	=	2520
	between		13.808	6.865	112.326	n	=	368
	within		0.861	42.232	55.226	T-bar	=	6.8478
% in remedial instruction	overall	0.03273	0.019	0.000	0.126	N	=	2520
	between		0.014	0.000	0.099	n	=	368
	within		0.012	-0.021	0.080	T-bar	=	6.8478
% Pupils transported	overall	0.34433	0.151	0.017	0.872	N	=	2520
	between		0.150	0.027	0.872	n	=	368
	within		0.026	0.140	0.485	T-bar	=	6.8478
% Pupils in 1.–6. grade	overall	0.64617	0.046	0.357	1.000	N	=	2520
	between		0.045	0.370	1.000	n	=	368
	within		0.021	0.507	0.747	T-bar	=	6.8478
% Non-Finnish -speaking pupils	overall	0.05117	0.186	0.000	1.000	N	=	2520
	between		0.194	0.000	1.000	n	=	368
	within		0.006	-0.021	0.134	T-bar	=	6.8478
Average school size	overall	4.63686	0.514	2.565	6.012	N	=	2520
	between		0.523	2.620	5.941	n	=	368
	within		0.087	4.196	5.637	T-bar	=	6.8478
Square average school size	overall	21.7648	4.860	6.579	36.150	N	=	2520
	between		4.895	6.865	35.293	n	=	368
	within		0.801	17.771	31.036	T-bar	=	6.8478

(Table 13 cont.)

Variable		Mean	Std. Dev	Min	Max			Observations
Education index	overall	233.418	44.956	142.000	531.000	N	=	2520
	between		43.442	150.286	518.286	n	=	368
	within		11.210	205.275	280.561	T-bar	=	6.8478
% Socialists in the council	overall	0.29195	0.132	0.000	0.704	N	=	2520
	between		0.132	0.000	0.704	n	=	368
	within		0.021	0.181	0.440	T-bar	=	6.8478
Costal area	overall	0.1373	0.410	0.000	2.000	N	=	2520
	between		0.433	0.000	2.000	n	=	368
	within		0.000	0.137	0.137	T-bar	=	6.8478
Upper secondary school	overall	0.7817	0.413	0.000	1.000	N	=	2520
(dummy)	between		0.414	0.000	1.000	n	=	368
	within		0.030	-0.075	1.067	T-bar	=	6.9804

Table 14 Calculation method for productivity effects in panel data models

We calculate the productivity effects Δp of each explanatory variable by multiplying parameter coefficient α with the average absolute change in variable x in the study period (1). After that we divide multiplication with the average efficiency (e) of the whole period, which in this case is 0.72.

$$\Delta p = \frac{\alpha dx}{e} \qquad (1)$$

For the variables in logarithmic form the mathematical method differs a bit from previous, because the change in variable x is now measured in percentages (2).

$$\Delta p = \frac{\alpha \left(\frac{dx}{x_0} \right)}{e} \qquad (2)$$

The combined effect for the productivity effect of the logarithmic variable and its square can be calculated by summing the coefficient of the logarithmic variable α with the coefficient of the square variable β multiplied by 2 (3). Otherwise the method is the same as previous.

$$\Delta p = \frac{\alpha + 2\beta\left(dx / x_0 \right)}{e} \qquad (3)$$

Table 15 Inefficiency scores from cross-section estimations by distribution assumption

Year	Mean	Min	Max	Std. Deviation
Half-Normal				
1998	0.10	0.01	0.44	0.07
1999	0.10	0.01	0.45	0.07
2000	0.09	0.01	0.45	0.07
2001	0.09	0.02	0.36	0.06
2002	0.09	0.01	0.44	0.07
2003	0.10	0.01	0.48	0.07
2004	0.08	0.01	0.39	0.06
Truncated-Normal				
1998	0.07	0.01	0.42	0.06
1999	0.07	0.01	0.42	0.06
2000	0.07	0.01	0.43	0.06
2001	0.06	0.01	0.35	0.05
2002	0.07	0.01	0.45	0.06
2003	0.09	0.01	0.47	0.07
2004	N/A	N/A	N/A	N/A
Exponential				
1998	0.07	0.01	0.42	0.06
1999	0.07	0.01	0.42	0.06
2000	0.06	0.01	0.43	0.06
2001	0.06	0.01	0.35	0.05
2002	0.07	0.01	0.45	0.06
2003	0.07	0.01	0.46	0.06
2004	0.06	0.01	0.44	0.05

Results for 2004 not available due to estimation problems with this data

Table 16 Inefficiency scores of panel data models in 1998–2004

Year	Mean	Min	Max	Std. Deviation
True fixed effect	Truncated			
1998	0.13	0.07	0.23	0.03
1999	0.13	0.06	0.26	0.03
2000	0.13	0.06	0.40	0.03
2001	0.13	0.08	0.25	0.02
2002	0.13	0.08	0.35	0.03
2003	0.13	0.08	0.28	0.03
2004	0.13	0.05	0.31	0.03
True fixed effect	Half normal			
1998	0.12	0.05	0.29	0.04
1999	0.12	0.05	0.31	0.04
2000	0.12	0.05	0.45	0.04
2001	0.13	0.06	0.31	0.03
2002	0.12	0.06	0.24	0.03
2003	0.12	0.06	0.22	0.03
2004	0.11	0.05	0.29	0.04
Pooled panel	Truncated			
1998	0.08	0.01	0.24	0.05
1999	0.08	0.02	0.24	0.05
2000	0.08	0.01	0.24	0.05
2001	0.08	0.02	0.24	0.05
2002	0.08	0.01	0.24	0.05
2003	0.08	0.02	0.24	0.05
2004	0.08	0.01	0.24	0.05
Pooled panel	Half normal			
1998	0.11	0.02	0.30	0.06
1999	0.11	0.03	0.30	0.06
2000	0.11	0.02	0.30	0.06
2001	0.11	0.03	0.30	0.06
2002	0.11	0.02	0.30	0.06
2003	0.11	0.02	0.30	0.06
2004	0.11	0.02	0.30	0.06

Figure 12 The effect of heteroscedasticity on average inefficiency scores

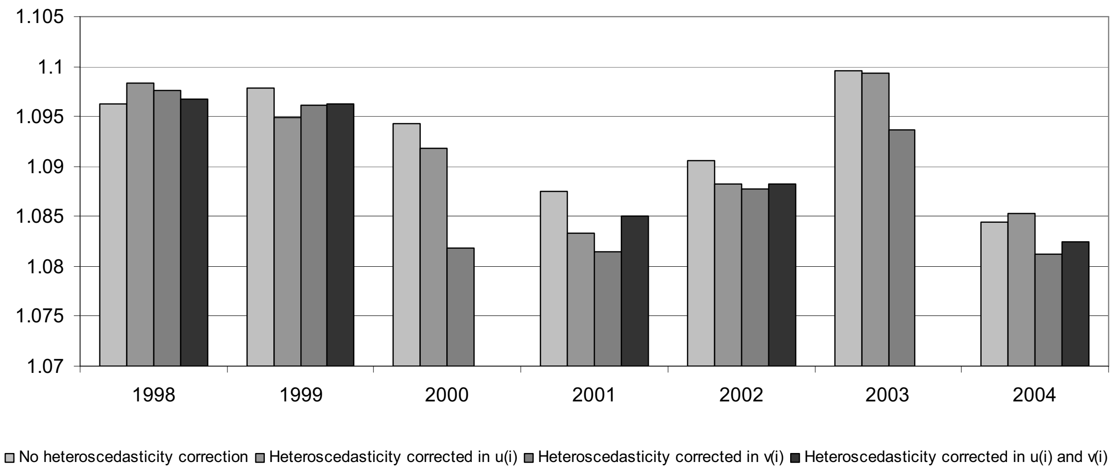


Table 17 Comparison of the time variant and invariant model

Variable	Time invariant inefficiency model*	Time varying inefficiency model*
Average salary	0.087	0.081
	(4.10)**	(3.83)**
Grade point average	-0.008	-0.009
	(1.32)	(1.44)
% To upper secondary schooling	0.012	0.011
	(0.47)	(0.45)
Pupils	-0.421	-0.414
	(10.13)**	(10.70)**
Square pupils	0.025	0.025
	(8.84)**	(9.20)**
% Pupils in remedial instruction	0.258	0.287
	(2.88)**	(3.33)**
% Pupils transported	0.112	0.095
	(4.52)**	(3.93)**
% Pupils in 1.–6. grade	-0.127	-0.130
	(3.43)**	(3.54)**
% Non-Finnish - speaking pupils	0.113	0.104
	(4.53)**	(4.26)**
Taxable income/inhabitant	0.027	0.032
	(1.11)	(1.29)
Average school size	-0.669	-0.591
	(9.59)**	(8.45)**
Square school size	0.059	0.052
	(7.78)**	(6.86)**
Education index	-0.000	0.000
	(0.21)	(0.33)
% Socialists in the council	0.000	-0.001
	(0.02)	(0.05)
Costal area	0.020	0.007
	(1.76)	(0.60)
Upper secondary school (dummy)	0.051	0.044
	(4.90)**	(4.36)**
Constant	10.752	10.529
	(31.79)**	(31.18)**
		.0275335
TEST for $\eta=0$		(5.40)**

*Robust t-values in parentheses. Year dummies suppressed.

Table 18 The estimation results for year 2000 using PISA-data

	reading	math	science	all
Pupil-teacher ratio	0.002	0.003	0.000	0.002
	(0.67)	(1.37)	(0.15)	(0.78)
Parents' occupational status	0.183	0.122	0.153	0.153
	(5.98)**	(4.11)**	(4.73)**	(5.50)**
% Share of teachers with university degree	0.034	0.049	0.058	0.047
	(1.03)	(1.40)	(1.55)	(1.47)
% Full time teachers	0.052	0.029	0.065	0.050
	(1.80)	(1.05)	(2.11)*	(1.87)
School size	-0.007	-0.012	-0.007	-0.009
	(0.77)	(1.31)	(0.68)	(1.03)
% Non-Finnish-speaking pupils	-0.073	-0.032	-0.080	-0.061
	(4.22)**	(1.92)	(4.12)**	(3.83)**
% female	0.097	0.111	0.094	0.102
	(1.57)	(1.85)	(1.40)	(1.79)
% pupils receiving remedial instruction	0.047	-0.094	0.025	-0.008
	(0.41)	(0.86)	(0.20)	(0.08)
lnsig2v:Constant	-7.001	-7.129	-7.067	-7.259
	(13.76)**	(16.08)**	(12.91)**	(16.39)**
lnsig2u:Constant	-7.126	-6.944	-6.416	-6.991
	(4.48)**	(6.72)**	(7.55)**	(7.26)**
Constant	5.526	5.756	5.611	5.626
	(42.54)**	(48.60)**	(42.51)**	(49.90)**
Observations	102	102	102	102

Absolute value of z statistics in parentheses
* significant at 5%; ** significant
at 1%

Table 19 Cost inefficiency of the municipalities 2000–2004[34]

	2000	2001	2002	2003	2004
Alahärmä	0.02	-	-	-	-
Alajärvi	0.08	0.09	0.10	0.11	0.10
Alastaro	0.05	0.07	0.05	0.06	0.05
Alavieska	0.06	0.08	0.07	0.07	0.05
Alavus	0.03	0.03	0.02	0.01	0.03
Anjalankoski	0.11	0.14	0.12	0.14	0.12
Asikkala	0.09	0.06	0.08	0.07	0.09
Askola	0.03	0.02	0.03	0.02	0.02
Dragsfjärd	0.24	0.13	0.13	0.15	0.13
Elimäki	0.03	0.04	0.05	0.06	0.05
Eno	0.09	0.11	0.10	0.04	0.03
Enonkoski	0.07	0.08	0.08	0.13	0.20
Enontekiö	0.44	0.34	0.38	0.36	0.28
Espoo	0.12	0.13	0.11	0.14	0.10
Eura	0.07	0.05	0.08	0.13	0.11
Eurajoki	0.06	0.05	0.04	0.03	0.04
Evijärvi	0.07	0.05	0.04	0.09	0.09
Forssa	0.12	0.11	0.09	0.10	0.08
Haapajärvi	0.10	0.08	0.08	0.05	0.06
Haapavesi	0.05	0.06	0.04	0.03	0.05
Hailuoto	0.22	0.22	0.20	0.30	0.20
Halikko	0.02	0.03	0.04	0.03	0.03
Halsua	0.10	0.03	0.06	0.11	0.09
Hamina	0.19	0.13	0.09	0.10	0.10
Hankasalmi	0.02	0.02	0.02	0.02	0.04
Hanko	0.20	0.13	0.25	0.27	0.10
Harjavalta	0.06	0.02	0.04	0.03	0.04
Hartola	0.16	0.15	0.21	0.16	0.17
Hattula	0.06	0.06	0.06	0.09	0.10
Hauho	0.11	0.09	0.14	0.07	0.08
Haukipudas	0.10	0.15	0.10	0.14	0.12
Haukivuori	0.09	0.06	0.05	0.06	0.09
Hausjärvi	0.08	0.06	0.06	0.04	0.03
Heinola	0.09	0.13	0.13	0.13	0.12
Heinävesi	0.22	0.17	0.12	0.15	0.11
Helsinki	0.17	0.18	0.16	0.19	0.10
Himanka	0.25	0.17	0.25	0.19	0.12
Hirvensalmi	0.02	0.03	0.05	0.05	0.05
Hollola	0.04	0.05	0.07	0.08	0.05
Honkajoki	0.04	0.02	0.03	0.02	0.03
Houtskari	0.02	-	-	-	-
Huittinen	0.02	0.02	0.02	0.02	0.03
Humppila	0.05	0.08	0.06	0.04	0.05
Hyrynsalmi	0.21	0.24	0.20	0.23	0.17
Hyvinkää	0.06	0.07	0.08	0.09	0.06
Hämeenkyrö	0.04	0.07	0.05	0.04	0.05

[34] The results are based on SFA estimation with cross-section data. The rough interpretation of the figures is so that the smaller the figure, the better.

	2000	2001	2002	2003	2004
Hämeenlinna	0.03	0.03	0.03	0.04	0.04
Ii	0.02	0.03	0.02	0.02	0.03
Iisalmi	0.04	0.06	0.08	0.05	0.05
Iitti	0.02	0.03	0.03	0.02	0.05
Ikaalinen	0.06	0.05	0.05	0.03	0.04
Ilmajoki	0.07	0.07	0.07	0.08	0.08
Ilomantsi	0.19	0.17	0.17	0.24	0.17
Imatra	0.16	0.13	0.15	0.12	0.10
Inari	0.34	0.36	0.44	0.48	0.37
Iniö	-	-	-	0.02	0.02
Isojoki	0.09	0.07	0.12	0.07	0.07
Isokyrö	0.07	0.05	0.05	0.07	0.05
Jalasjärvi	0.11	0.08	0.07	0.05	0.06
Janakkala	0.04	0.02	0.03	0.02	0.03
Joensuu	0.07	0.04	0.04	0.05	0.05
Jokioinen	0.05	0.07	0.05	0.05	0.04
Joroinen	0.05	0.05	0.06	0.06	0.08
Joutsa	0.03	0.04	0.03	0.04	0.04
Joutseno	0.21	0.20	0.22	0.22	0.16
Juankoski	0.08	0.07	0.13	0.11	0.05
Jurva	0.08	0.10	0.11	0.12	0.12
Juuka	0.12	0.18	0.13	0.19	0.09
Juupajoki	0.06	0.06	0.03	0.04	0.04
Juva	0.10	0.07	0.08	0.09	0.09
Jyväskylä	0.07	0.09	0.10	0.15	0.11
Jyväskylän mlk	0.08	0.07	0.07	0.07	0.06
Jämijärvi	0.05	0.03	0.04	0.05	0.07
Jämsä	0.04	0.05	0.06	0.09	0.08
Jämsänkoski	0.16	0.11	0.09	0.08	0.09
Järvenpää	0.08	0.05	0.04	0.04	0.05
Kaarina	0.03	0.05	0.04	0.04	0.04
Kaavi	0.11	0.07	0.06	0.05	0.07
Kajaani	0.13	0.13	0.17	0.15	0.13
Kalajoki	0.04	0.05	0.05	0.04	0.04
Kalvola	0.11	0.08	0.11	0.17	0.12
Kangasala	0.04	0.03	0.04	0.04	0.05
Kangasniemi	0.03	0.04	0.03	0.02	0.03
Kankaanpää	0.04	0.07	0.07	0.06	0.06
Kannonkoski	0.11	0.16	0.22	0.15	0.19
Kannus	0.09	0.07	0.05	0.04	0.06
Karinainen	0.03	0.04	0.06	0.06	0.08
Karjaa	0.04	0.05	0.05	0.07	0.08
Karkkila	0.02	0.03	0.03	0.04	0.05
Karstula	0.20	0.16	0.16	0.16	0.08
Karttula	0.04	0.03	0.05	0.05	0.04
Karvia	0.11	0.10	0.11	0.18	0.16
Kaskinen	0.05	0.05	0.03	0.11	0.15
Kauhajoki	0.07	0.11	0.11	0.12	0.13
Kauhava	0.09	0.07	0.07	0.07	0.04
Kauniainen	0.16	0.21	0.23	0.33	0.21
Kaustinen	0.07	0.06	0.04	0.08	0.07

	2000	2001	2002	2003	2004
Keitele	0.16	0.14	0.10	0.07	0.06
Kemi	0.04	0.08	0.13	0.17	0.09
Kemijärvi	0.17	0.14	0.18	0.22	0.17
Keminmaa	0.20	0.19	0.16	0.23	0.17
Kemiö	0.04	0.04	0.04	0.04	0.05
Kempele	0.17	0.10	0.11	0.20	0.13
Kerava	0.02	0.03	0.04	0.03	0.04
Kerimäki	0.07	0.08	0.10	0.05	0.06
Kestilä	0.06	0.03	-	-	-
Kesälahti	0.28	0.21	0.25	0.26	0.14
Keuruu	0.20	0.21	0.22	0.26	0.21
Kihniö	0.03	0.06	0.05	0.08	0.06
Kiihtelysvaara	0.08	0.03	0.05	0.04	0.07
Kiiminki	0.15	0.15	0.17	0.22	0.17
Kinnula	0.04	0.03	0.03	0.06	0.06
Kirkkonummi	0.11	0.09	0.15	0.18	0.12
Kitee	0.06	0.08	0.09	0.10	0.12
Kittilä	0.29	0.24	0.20	0.30	0.23
Kiukainen	0.09	0.07	0.07	0.08	0.05
Kiuruvesi	0.06	0.08	0.04	0.06	0.05
Kivijärvi	0.16	0.11	0.05	0.12	0.07
Kokemäki	0.09	0.07	0.09	0.11	0.10
Kokkola	0.07	0.09	0.09	0.11	0.08
Kolari	0.16	0.15	0.14	0.14	0.09
Konnevesi	0.01	0.04	0.04	0.03	0.06
Kontiolahti	0.10	0.12	0.14	0.21	0.22
Korpilahti	0.05	0.04	0.09	0.08	0.10
Korppoo	0.11	0.05	0.07	0.25	0.22
Kortesjärvi	0.02	0.02	0.02	0.01	0.02
Koski Tl	0.06	0.08	0.05	0.19	0.06
Kotka	0.05	0.05	0.04	0.03	0.04
Kouvola	0.07	0.07	0.06	0.04	0.06
Kristiinankaupunki	0.11	0.08	0.10	0.11	0.08
Kruunupyy	0.15	0.09	0.05	0.05	0.03
Kuhmo	0.30	0.30	0.31	0.29	0.29
Kuhmoinen	0.14	0.16	0.23	0.23	0.18
Kuivaniemi	0.14	0.12	0.14	0.11	0.12
Kuopio	0.05	0.07	0.09	0.08	0.07
Kuorevesi	0.06	-	-	-	-
Kuortane	0.07	0.04	0.06	0.08	0.05
Kurikka	0.03	0.06	0.05	0.04	0.04
Kuru	0.04	0.06	0.07	0.07	0.08
Kuusamo	0.11	0.13	0.16	0.26	0.11
Kuusankoski	0.13	0.13	0.12	0.12	0.09
Kyyjärvi	0.21	0.17	0.21	0.18	0.18
Kälviä	0.08	0.10	0.10	0.08	0.06
Kärkölä	0.05	0.02	0.02	0.03	0.03
Kärsämäki	0.04	0.03	0.03	0.02	0.04
Köyliö	0.10	0.09	0.04	0.03	0.03
Lahti	0.05	0.08	0.06	0.07	0.11
Laihia	0.15	0.10	0.08	0.04	0.09

	2000	2001	2002	2003	2004
Laitila	0.06	0.05	0.05	0.05	0.06
Lammi	0.07	0.06	0.07	0.09	0.05
Lapinjärvi	0.10	0.05	0.10	0.04	0.05
Lapinlahti	0.11	0.12	0.05	0.03	0.05
Lappajärvi	0.17	0.12	0.15	0.09	0.16
Lappeenranta	0.07	0.05	0.08	0.12	0.10
Lapua	0.12	0.08	0.10	0.08	0.06
Laukaa	0.08	0.15	0.13	0.12	0.10
Lavia	0.07	0.04	0.06	0.05	0.04
Lehtimäki	0.04	0.02	0.06	0.06	0.08
Lemi	0.11	0.08	0.09	0.13	0.08
Lempäälä	0.08	0.08	0.06	0.11	0.07
Leppävirta	0.11	0.09	0.13	0.13	0.10
Lieksa	0.17	0.17	0.18	0.20	0.19
Lieto	0.08	0.06	0.08	0.08	0.07
Liminka	0.04	0.10	0.06	0.11	0.09
Liperi	0.17	0.21	0.22	0.22	0.17
Lohja	0.05	0.06	0.05	0.05	0.05
Lohtaja	0.07	0.09	0.04	0.05	0.05
Loimaa	0.05	0.05	0.06	0.05	0.06
Loimaan kunta	0.10	0.13	0.08	0.15	0.09
Loppi	0.05	0.04	0.05	0.03	0.05
Loviisa	0.14	0.12	0.09	0.07	0.06
Lumijoki	-	-	0.09	0.19	0.17
Luopioinen	0.02	0.02	0.04	0.03	0.04
Luoto	0.10	0.10	0.04	0.04	0.04
Luumäki	0.11	0.06	0.10	0.07	0.04
Luvia	0.17	0.08	0.11	0.13	0.11
Maalahti	0.10	0.05	0.06	0.10	0.06
Maaninka	0.06	0.03	0.02	0.03	0.03
Masku	0.03	0.07	0.05	0.02	0.06
Merijärvi	0.02	0.03	0.04	0.02	0.02
Merikarvia	0.12	0.11	0.13	0.11	0.09
Miehikkälä	0.14	0.09	0.07	0.08	0.08
Mikkeli	0.20	0.11	0.10	0.08	0.06
Mikkelin mlk	0.06	-	-	-	-
Mouhijärvi	0.03	0.03	0.02	0.02	0.04
Muhos	0.05	0.10	0.07	0.05	0.04
Multia	0.11	0.15	0.10	0.12	0.06
Muonio	0.23	0.27	0.26	0.34	0.29
Mustasaari	0.07	0.07	0.08	0.11	0.08
Muurame	0.15	0.14	0.11	0.17	0.12
Mynämäki	0.03	0.05	0.04	0.03	0.03
Mäntsälä	0.08	0.05	0.04	0.03	0.06
Mänttä	0.11	0.09	0.11	0.09	0.06
Mäntyharju	0.13	0.11	0.11	0.11	0.08
Naantali	0.20	0.13	0.10	0.05	0.07
Nakkila	0.05	0.04	0.07	0.06	0.06
Nastola	0.08	0.10	0.07	0.17	0.06
Nilsiä	0.03	0.03	0.04	0.05	0.03
Nivala	0.05	0.08	0.13	0.13	0.07

	2000	2001	2002	2003	2004
Nokia	0.18	0.08	0.09	0.08	0.07
Noormarkku	0.03	0.03	0.03	0.02	0.04
Nousiainen	0.07	0.03	0.05	0.02	0.03
Nummi-Pusula	0.04	0.05	0.06	0.05	0.05
Nurmes	0.07	0.07	0.05	0.08	0.08
Nurmijärvi	0.08	0.04	0.05	0.05	0.05
Nurmo	0.07	0.04	0.04	0.04	0.04
Närpiö	0.02	0.02	0.02	0.02	0.03
Orimattila	0.08	0.06	0.07	0.09	0.08
Orivesi	0.03	0.02	0.03	0.02	0.03
Oulainen	0.11	0.10	0.08	0.11	0.06
Oulu	0.08	0.10	0.11	0.15	0.11
Oulunsalo	0.06	0.05	0.05	0.08	0.06
Outokumpu	0.04	0.12	0.15	0.14	0.12
Padasjoki	0.05	0.07	0.08	0.09	0.07
Paimio	0.12	0.10	0.08	0.06	0.07
Paltamo	0.18	0.15	0.16	0.19	0.10
Parainen	0.18	0.13	0.12	0.16	0.12
Parikkala	0.04	0.06	0.05	0.04	0.04
Parkano	0.05	0.09	0.11	0.13	0.13
Pattijoki	0.08	0.09	0.11	-	-
Pedersöre	0.03	0.03	0.05	0.07	0.06
Pelkosenniemi	0.34	0.27	0.29	0.29	0.23
Pello	0.04	0.05	0.09	0.12	0.08
Perho	0.10	0.10	0.14	0.15	0.12
Perniö	0.10	0.08	0.10	0.11	0.12
Pertunmaa	0.21	0.14	0.21	0.24	0.14
Peräseinäjoki	0.12	0.15	0.19	0.19	0.13
Petäjävesi	0.19	0.11	0.07	0.05	0.06
Pieksämäen mlk	0.06	0.08	0.07	0.07	-
Pieksämäki	0.05	0.05	0.04	0.04	0.04
Pieksänmaa	-	-	-	-	0.10
Pielavesi	0.03	0.03	0.02	0.03	0.05
Pietarsaari	0.14	0.12	0.10	0.13	0.10
Pihtipudas	0.10	0.04	0.07	0.06	0.08
Piikkiö	0.03	0.04	0.07	0.12	0.09
Pirkkala	0.07	0.06	0.06	0.05	0.06
Polvijärvi	0.02	0.02	0.08	0.05	0.06
Pomarkku	0.04	0.08	0.10	0.13	0.11
Pori	0.04	0.04	0.04	0.03	0.04
Pornainen	0.05	0.07	0.08	0.08	0.06
Porvoo	0.05	0.06	0.04	0.04	0.04
Posio	0.17	0.13	0.14	0.19	0.20
Pudasjärvi	0.22	0.23	0.25	0.26	0.23
Pulkkila	0.02	0.02	0.02	0.02	0.03
Punkaharju	0.09	0.06	0.05	0.03	0.05
Punkalaidun	0.06	0.05	0.05	0.04	0.07
Puolanka	0.32	0.32	0.33	0.24	0.16
Puumala	0.18	0.13	0.23	0.24	0.20
Pyhtää	0.06	0.03	0.05	0.04	0.06
Pyhäjoki	0.09	0.06	0.06	0.09	0.09

	2000	2001	2002	2003	2004
Pyhäjärvi	0.08	0.08	0.12	0.13	0.11
Pyhäselkä	0.03	0.05	0.03	0.05	0.04
Pälkäne	0.02	0.02	0.01	0.01	0.01
Raahe	0.11	0.12	0.14	0.14	0.09
Raisio	0.07	0.03	0.02	0.02	0.04
Rantasalmi	0.12	0.08	0.02	0.03	0.03
Rantsila	0.13	0.19	0.25	0.23	0.23
Ranua	0.10	0.12	0.11	0.13	0.12
Rauma	0.08	0.10	0.13	0.10	0.07
Rautalampi	0.10	0.11	0.07	0.04	0.03
Rautavaara	0.03	0.07	0.11	0.07	0.05
Rautjärvi	0.17	0.17	0.12	0.13	0.07
Reisjärvi	0.07	0.03	0.04	0.07	0.07
Riihimäki	0.08	0.05	0.06	0.05	0.03
Ristiina	0.12	0.08	0.07	0.14	0.07
Ristijärvi	0.19	0.18	0.07	0.07	0.07
Rovaniemen mlk	0.16	0.16	0.16	0.18	0.20
Rovaniemi	0.09	0.13	0.09	0.12	0.08
Ruokolahti	0.17	0.18	0.13	0.14	0.09
Ruovesi	0.10	0.07	0.06	0.06	0.07
Rusko	0.04	0.03	0.05	0.04	0.03
Ruukki	0.16	0.08	0.10	0.10	0.06
Rääkkylä	0.11	0.14	0.08	0.08	0.06
Saarijärvi	0.03	0.03	0.03	0.03	0.06
Sahalahti	0.02	0.03	0.03	0.04	0.02
Salla	0.21	0.27	0.27	0.33	0.29
Salo	0.06	0.10	0.12	0.10	0.10
Sauvo	0.04	0.04	0.04	0.07	0.05
Savitaipale	0.04	0.03	0.04	0.02	0.03
Savonlinna	0.04	0.03	0.05	0.04	0.04
Savonranta	0.05	0.03	0.04	0.03	0.02
Savukoski	0.45	0.29	0.20	0.24	0.15
Seinäjoki	0.06	0.06	0.07	0.05	0.07
Sievi	0.04	0.04	0.05	0.04	0.02
Siikainen	0.14	0.09	0.05	0.17	0.09
Siikajoki	0.03	0.06	0.06	0.06	0.11
Siilinjärvi	0.09	0.07	0.07	0.08	0.07
Simo	0.04	0.05	0.04	0.06	0.04
Sipoo	0.04	0.02	0.03	0.02	0.02
Sodankylä	0.21	0.24	0.26	0.29	0.26
Soini	0.06	0.08	0.04	0.03	0.07
Somero	0.03	0.04	0.07	0.06	0.07
Sonkajärvi	0.06	0.03	0.04	0.10	0.02
Sotkamo	0.17	0.19	0.21	0.21	0.15
Sulkava	0.14	0.12	0.10	0.09	0.05
Suolahti	0.14	0.09	0.11	0.12	0.10
Suomussalmi	0.21	0.28	0.38	0.38	0.27
Suonenjoki	0.06	0.11	0.12	0.14	0.11
Sysmä	0.16	0.15	0.21	0.21	0.13
Säkylä	0.11	0.06	0.06	0.11	0.12
Taipalsaari	-	-	-	0.04	0.03

	2000	2001	2002	2003	2004
Taivalkoski	0.22	0.13	0.13	0.15	0.09
Taivassalo	0.18	0.12	0.13	0.22	0.13
Tammela	0.03	0.03	0.03	0.03	0.03
Tammisaari	0.09	0.07	0.05	0.10	0.10
Tampere	0.04	0.03	0.03	0.04	0.06
Tarvasjoki	-	-	0.11	0.13	0.09
Tervo	0.05	0.06	0.04	0.08	0.12
Tervola	0.13	0.10	0.11	0.12	0.12
Teuva	0.10	0.05	0.08	0.18	0.09
Tohmajärvi	0.05	0.05	0.05	0.06	0.11
Toholampi	0.02	0.12	0.07	0.13	0.04
Toijala	0.07	0.04	0.04	0.04	0.04
Toivakka	0.14	0.17	0.15	0.12	0.09
Tornio	0.19	0.15	0.18	0.19	0.14
Turku	0.06	0.04	0.04	0.07	0.06
Tuupovaara	0.10	0.17	0.12	0.17	0.14
Tuusniemi	0.03	0.03	0.03	0.02	0.03
Tuusula	0.02	0.02	0.02	0.02	0.03
Tyrnävä	0.13	0.11	0.11	0.18	0.09
Töysä	0.04	0.04	0.04	0.03	0.05
Ulvila	0.03	0.04	0.03	0.03	0.04
Urjala	0.09	0.08	0.09	0.08	0.05
Utajärvi	0.19	0.16	0.09	0.14	0.10
Utsjoki	0.07	0.34	0.28	0.33	0.39
Uurainen	0.20	0.20	0.22	0.23	0.17
Uusikaarlepyy	0.11	0.08	0.10	0.16	0.13
Uusikaupunki	0.08	0.06	0.05	0.04	0.04
Vaala	0.11	0.04	0.02	0.02	0.07
Vaasa	0.14	0.15	0.10	0.09	0.08
Valkeakoski	0.11	0.08	0.12	0.06	0.08
Valkeala	0.08	0.08	0.10	0.06	0.07
Valtimo	0.09	0.07	0.04	0.08	0.12
Vammala	0.06	0.06	0.06	0.05	0.05
Vantaa	0.06	0.03	0.04	0.05	0.04
Varkaus	0.07	0.04	0.10	0.10	0.10
Varpaisjärvi	0.04	0.06	0.05	0.09	0.08
Vehkalahti	0.07	0.07	0.16	-	-
Vehmaa	0.04	0.04	0.04	0.03	0.05
Vehmersalmi	0.11	0.07	0.07	0.14	0.06
Velkua	-	0.04	0.04	-	0.07
Vesanto	0.04	0.03	0.03	0.05	0.04
Vesilahti	0.10	0.08	0.08	0.07	0.06
Veteli	0.07	0.07	0.10	0.11	0.05
Vieremä	0.04	0.04	0.04	0.02	0.03
Vihanti	0.05	0.05	0.04	0.06	0.09
Vihti	0.04	0.09	0.09	0.10	0.07
Viiala	0.09	0.10	0.09	0.07	0.06
Viitasaari	0.10	0.08	0.13	0.13	0.03
Vilppula	0.22	0.16	0.19	0.14	0.14
Vimpeli	0.10	0.10	0.15	0.14	0.04
Virolahti	0.05	0.06	0.08	0.08	0.07

	2000	2001	2002	2003	2004
Virrat	0.06	0.09	0.08	0.05	0.05
Vuolijoki	0.39	0.04	0.06	0.12	0.11
Vähäkyrö	0.12	0.09	0.08	0.08	0.06
Vöyri	0.09	0.09	0.08	0.11	0.08
Ylihärmä	0.06	0.05	0.04	0.04	0.04
Yli-Ii	0.07	0.07	0.06	0.05	0.08
Ylikiiminki	0.05	0.07	0.08	0.05	0.13
Ylistaro	0.04	0.05	0.06	0.07	0.07
Ylitornio	0.12	0.07	0.12	0.15	0.10
Ylivieska	0.03	0.02	0.03	0.03	0.05
Yläne	0.14	0.12	0.07	0.11	0.11
Ylöjärvi	0.07	0.06	0.04	0.04	0.06
Ypäjä	0.09	0.07	0.08	0.08	0.07
Äetsä	0.03	0.03	0.02	0.02	0.03
Ähtäri	0.08	0.06	0.05	0.07	0.06
Äänekoski	0.04	0.04	0.04	0.03	0.04

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