Swedish School Results, Student Background, Competition and Efficiency

Christophe André, Jon Pareliussen, Hyunjeong Hwang

Received in March 2020

Christophe André
MSc, Senior Economist, OECD Economics Department. E-mail: christophe.andre@oecd.org
Jon Pareliussen
MSc, Economist, OECD Economics Department. E-mail: jon.pareliussen@oecd.org
Hyunjeong Hwang
PhD, Statistician, OECD Economics Department. E-mail: hyunjeong.hwang@oecd.org

Address: OECD, Economics Department, 2 rue André-Pascal, 75775 Paris Cedex 16.

Abstract. Sweden's declining results in the Programme for International Student Assessment (PISA) for 15-year olds and other international tests between 2000 and 2012 have raised concern about the efficiency of the Swedish school system, even though results improved recently. Furthermore, inequality in educational outcomes between socio-economic groups have widened. A specificity of the Swedish school system is that it allows free choice between public and private schools. This has triggered a lively debate on the implications of competition for school results and educational inequality. Against this backdrop, this paper presents an econometric analysis of lower secondary school performance in Sweden, using a panel covering most schools in the country over the period 2013–17. We find that for-profit private schools underperform non-profit and public schools on average, although with large heterogeneity. School competition is associated with lower results in schools with a high share of pupils from weaker socio-economic backgrounds, which is consistent with negative peer effects in left-behind schools. Panel Stochastic Frontier Analysis points to a relatively narrow distribution of inefficiency across schools, with relatively few schools performing very poorly after controlling for their resources and the socio-economic background of their pupils. These results call for better targeting resources towards supporting the pupils most in need and steering competition and school choice so that they benefit pupils from all socio-economic groups equally.

Keywords: Sweden, education, efficiency, competition, stochastic frontier analysis.

DOI: 10.17323/1814-9545-2020-3-8-36

Introduction

Sweden has a strong knowledge-based economy, which relies heavily on a highly skilled workforce. Declining results in the Programme for International Student Assessment (PISA) for 15-year olds, as well as in other international tests, between the early 2000s and 2012 have sparked a lively public and academic debate on the effectiveness and efficiency of the Swedish education system. Even though Sweden's rankings climbed to seventh in reading, twelfth in mathematics and fourteenth in science among OECD countries in the 2018 PISA vintage [OECD, 2019], challenges remain, notably inequal results related to socio-economic status, which is comparable to other OECD countries, and declining performance among the lowest-performing pupils, partly due to rising immigration. School performance also attracted attention from foreign researchers, as the Swedish education system displays some unique characteristics. In particular, it is the only OECD country with a substantial for-profit school sector entirely funded by the public purse, which has turned it into a top spot for exploring the impact of competition on school results. As the decline in results started in the wake of a series of reforms, which decentralised the school system and introduced choice, competition and management by objectives in the early 1990s, there is a presumption that these reforms may have contributed to weakening educational performance. However, other factors may influence test results, including cost savings in the public sector triggered by the 1990s economic crisis, rising immigration from non-European countries and growing socio-economic inequality. Hence, it is essential to disentangle the different factors affecting school results to design adequate policy responses.

This article presents an econometric analysis of school performance, as measured by average scores in national mathematics tests in a panel of Swedish lower secondary schools covering the period 2013–17. It includes both conventional school-level panel regressions and stochastic frontier analysis (SFA), which sheds light on the level and distribution of school inefficiency.

The main findings are as follows:

- Non-profit private school results are on par with those of public schools, but for-profit schools show somewhat lower results on average, controlling for other factors. However, this effect masks large heterogeneity across schools. The under-performance of for-profit schools is more pronounced in schools with a weaker socio-economic mix of pupils, while non-profit private schools over-perform in that category of schools.
- An indicator of competition, based on the density of schools in the vicinity of each school, is negatively associated with test scores, albeit only in schools with a weak socio-economic mix of pupils. This result is confirmed using the share of pupils in private schools by municipality as a competition indicator.
- The relation between inputs and test scores varies between schools with weak and strong socio-economic mixes of pupils. In particular, the positive association between test scores and both spending per pupil and the share of certified teachers is stronger in weaker schools.
- Panel Stochastic Frontier Analysis indicates that relatively few

Swedish schools perform very poorly once educational inputs and pupil socio-economic characteristics are taken into account.

- Overall, our results suggest that better targeting resources towards the pupils most in need and better steering competition and school choice, so that they benefit pupils from all socio-economic groups equally, has potential to improve school results.

Overview of Swedish secondary education

Compulsory education is provided in one single structure covering children aged 6 to 16, corresponding to primary school and lower secondary school (ISCED levels 1 and 2). About 1,024,000 pupils were enrolled in the Swedish compulsory school system in the school year 2016/17. Most pupils attended municipal schools, while 154,000 (approximately 15%) attended private (including international) schools. The school system has been decentralised since the early 1990s. Municipalities and private school providers are responsible for primary and secondary schools, including organisational development and control, and teacher training and competence development. School funding is set at the discretion of each municipality, with the exception of some targeted state grants.

Compulsory school pupils are entitled to a place in a municipal school based on proximity, but may choose another municipal school (usually within the municipality) or private school (regardless of location), subject to availability of vacancies. Private providers have their own admission systems, which need to be non-discriminatory. The usual admission criteria are siblings already admitted, geographical proximity and the time of application (first-come-first-served). Upper secondary admission is based on compulsory school grades, and not limited by municipal borders.

Rules guiding private schools are designed to create a level playing field between public and private schools. Private schools can be freely established following approval by the Swedish Schools Inspectorate. They follow the same rules as public schools, and teach the same curriculum (except for international schools), and they are subject to the same inspection regime as municipal schools.

Municipalities are compelled to finance compulsory and upper secondary education of resident children, including children attending a private school or a school run by a different municipality. Funding of resident children attending schools other than those run by the municipality is based on the actual cost of provision or the cost of organising the same programme in public schools in the home municipality. Schools (private and public) are not allowed to charge tuition fees.

Literature Review

A vast literature provides broad analysis of Swedish school result developments, effects of the 1990s reforms, inequality in education, segregation, and related policy issues [Gustafsson et al. 2016; OECD2015;

Swedish School Commission 2017; Swedish National Agency for Education 2018a]. We will focus on studies more closely related to this paper, namely those investigating the links between school competition and educational outcomes and those analysing efficiency using stochastic frontier analysis (SFA).

Several studies find a positive relationship between school competition and results in Sweden. Sandström and Bergström [2005], using a large sample of ninth graders in 34 municipalities in 1997/98, find a positive effect of competition, measured by the share of independent school pupils in the municipality, on national mathematics test scores and grades of public school pupils. Heller Sahlgren [2011], using school-level data from all Swedish schools with at least fifteen ninth grade pupils in 2005–09, finds that school competition improved educational attainment, as measured by grades. Böhlmark and Lindahl [2015] find positive effects from the share of pupils attending private schools on average grades within a municipality using a dataset covering ninth graders in the period 1988–2009. Wondratschek et al. [2013] use a measure based on the number of schools in the vicinity of pupils' homes covering the period 1987–2006, and find a significant but very small positive effect from having more choices available on marks at the end of compulsory schooling. Edmark et al. [2014] find that pupils from disadvantaged socio-economic groups or with an immigrant background did not benefit less than other children from the Swedish 1992 school choice reform.

However, Yang Hansen and Gustafsson [2016], using a counterfactual approach to differentiate school segregation from residential segregation, and Böhlmark et al. [2016], exploiting variation in school choice opportunities across municipalities, find evidence that segregation between natives and immigrants, and between pupils from different socio-economic backgrounds, has increased with school choice. Hinnerich and Vlachos [2017], with a value added approach (i. e. taking into account past achievements of pupils), find that pupils at upper-secondary voucher schools achieve on average somewhat lower scores on externally graded standardised tests in first year core courses, especially under-achieving pupils, but not immigrants.

A positive impact of competition on education outcomes is found in some US states. Borland and Howsen [1992] find that an increase in the degree of market concentration, measured by a Herfindahl index, lowers pupil achievement (standardised test scores) in Kentucky in 1989–90. Blair and Staley [1995], using school-district data from the six largest metropolitan statistical areas in Ohio, find a small positive influence of competition, measured by average test scores in neighbouring school districts, on standardised test scores. Dee [1998] finds that increased competition from private schools, measured by the proportion of pupils attending such schools, has a positive and significant impact on pupil attainment (high school graduation rates) in public schools, with data covering school districts in 18 US states in 1993–

94. Millimet and Collier [2008] apply a two-stage procedure to Illinois public school district data for 1997–98. First, they derive efficiency scores from a production function. Then, they estimate a spatial model to assess whether a school district's efficiency is affected by neighbouring districts' efficiency and find some evidence of positive spillovers, albeit depending on the school district's financial environment.

Misra et al. [2012] develop a Geographical Information System (GIS)-based school competition index for Mississippi, which they use as an explanatory variable for efficiency scores estimated through a production function. They find that competition from private schools increases public primary and high school efficiency significantly. Akyol [2016], using an agent-based simulation model of a representative US school district, finds that universal vouchers (as used in Sweden) have an ambiguous effect on pupils from low-income families. While pupils moving to better schools benefit, those staying in disadvantaged schools suffer from a negative peer effect, as pupils with higher abilities or from higher income families are more likely to change school. Targeted vouchers, subsidising pupils with lower abilities, are found to bring school districts the benefits of competition, while preventing the peer group deterioration observed with universal vouchers.

A number of studies look at Chile, which introduced school choice in 1981 through a national voucher programme. About half of lower secondary education pupils were enrolled in government dependent private institutions in 2017. Chile was the only OECD country with Sweden to have a large publicly funded for-profit sector, until it ended public funding of for-profit schools on equity grounds in 2015 [Pareliussen et al. 2019]. Notable differences between the Chilean and Swedish voucher programmes are that Chilean voucher schools have been allowed to charge additional tuition fees since 1993 and to select pupils since 2009 [Navarro-Palau 2017]. Hsieh and Urquiola (2006) find no evidence that choice improved average educational outcomes, such as test scores, repetition rates and years of schooling. They find evidence of increased sorting, with the best public school pupils tending to leave for private schools, a result confirmed by Elacqua [2012]. Navarro-Palau [2017] studies the impact of a further reform in 2008, which made vouchers dependent on the pupil's family income. She finds no improvement in the test scores of pupils most likely to move to private schools, but a rise in the test scores of pupils most likely to stay in public schools, suggesting the latter may have responded to increased competition by enhancing teaching quality.

Two studies use SFA to evaluate the efficiency of Swedish schools. Heshmati and Kumbhakar [1997] provide a SFA of Swedish primary and secondary schools in 1993–94. The analysis is very different from the one conducted in this paper, as the output variable is the number of pupils rather than average test scores. The study finds an average efficiency level of 90–92%, with a relatively narrow distribution. Holmberg [2017]'s analysis is closer to our paper. He performs a SFA of the efficiency of Swedish secondary schools from 2006/07 to 2015/16, using the average grade across subjects for ninth grade pupils as the output variable. The share of independent schools in the municipality, which is interpreted as a proxy for local competition, has a positive impact on results. Efficiency estimates are above 96% in all cases. However, the methodology applied by Holmberg [2017] is likely to overestimate efficiency. Indeed, Greene [2005]'s true random effects model is applied after a within-transformation of the data (i. e. on demeaned data), which wipes out any time-invariant inefficiency.

A number of studies use SFA to analyse the performance of education institutions in other countries. Conroy and Arguea [2008] look at public elementary schools in Florida in 1997–98, using mathematics and reading test scores as outputs. Average efficiency ranges from 94.9% to 95.9% depending on the output measure and the region of the State. Pereira and Moreira [2007] investigate the efficiency of secondary schools in Portugal, using the average score in the twelfth grade national examinations as output. SFA is performed on cross-sectional data for 2004–05 and on panel data for the same school year and the preceding one. The average efficiency scores are 93% to 94% in the cross-sectional analysis and 83% to 88% in the panel analysis, according to specifications. Private schools perform significantly better than public schools, essentially reflecting strong performance at the higher end of the distribution. Kirjavainen [2012] evaluates the efficiency of Finnish general upper secondary schools in 2000–04, using a range of panel SFA models. The output is the school's average score in the compulsory tests in the matriculation examination. Average inefficiency estimates vary depending on the model used, but most estimates range from 93% to 97%. Dancer and Blackburn [2017] study the efficiency of New South Wales (Australia) secondary schools in 2005–10. The output variable is the average score in the Higher School Certificate examinations at the end of Year 12. Average efficiency is about 96%, but with a long tail of relatively inefficient schools.

Sutherland et al. [2007] present a SFA school-level analysis covering a sample of 6204 schools in 30 OECD countries in 2003. This study, which uses OECD's Programme for International Pupil Assessment scores as the output measure, is a useful complement to country-specific analyses, as it provides efficiency estimates relative to an international efficiency frontier. The inputs include educational resources as well as a synthetic indicator of the socio-economic background of pupils. Median school-efficiency is 96% and 90% of schools are within a 10 percentage point range (in the preferred specification, with exponential distribution). Median school-efficiency ranges from 91% to 97% depending on the country (95% for Sweden), with the interval encompassing 90% of schools varying between 4 and 23 percentage points (6 for Sweden).

Our paper contributes to the literature in two ways. First, it investigates the link between school competition and performance using a density-based indicator in a panel of Swedish secondary schools between 2013 to 2017, controlling for a wide set of socio-economic and policy variables. Second, a panel stochastic frontier analysis (SFA) provides estimates of Swedish secondary schools efficiency.

Data and Descriptive Statistics

The empirical analysis is based on an unbalanced panel data set containing school-level and municipal-level data, covering 1,346 schools and 286 municipalities from 2013 to 2017.[1] The primary data source is the Swedish National Agency for Education's (Skolverket) online information system—SIRIS/SALSA [Swedish National Agency for Education, 2018b]. It provides school-level datasets on school performance, as well as teacher and pupil characteristics. Municipal-level data on demographics are collected from Statistics Sweden [Statistics Sweden, 2018a]. Finally, results from a survey of pupil satisfaction (Skolenkäten) are gathered from the Swedish School inspectorate [2018]. The data is merged by unique school and municipality identifiers.

Summary statistics are shown in Table 1. After removing a few outliers, the whole sample includes 4,878 observations, of which 3,735 relate to public schools (77%), 973 to for-profit schools (20%) and 170 to non-profit private schools (3%). The coverage varies slightly between years. On average over the five years, the sample covers two-thirds of the total number of schools, with a minimum of 58% in 2013 and a maximum of 72% in 2016.

The dependent variable is a simple school-level average mathematics score from the national test in the ninth grade. Vlachos [2018] finds evidence of systematic differences in grading standards between Swedish schools, and argues that the national test score in mathematics is more reliable than other subject scores, as grading is less subjective. The Swedish School Inspectorate [2013] found that mathematics has the smallest discrepancy between external and internal assessments among the core subjects in national tests, which also include Swedish and English.

The independent variables include a competition indicator based on school density, whose construction is described in the methodological section below, and a range of policy and socio-economic indicators. Four policy variables reflecting policy choices which can affect school performance. Spending per pupil refers to total expenditure on compulsory schools divided by the total number of pupils at the municipal level. According to the definition provided by Skolverket, the cost includes staff, teaching tools, school libraries, school management, administration, and professional development of teachers and staff. The school-level share of certified teachers qualified to teach in their subject (here mathematics) is a commonly used predictor of pu-

[1] The dataset expands in time and scope the dataset used in Vlachos (2018).

Table 1. **Summary statistics of main variables**

	Mean	Standard deviation	Min	Max
Whole sample				
Mathematics test score	11.5	2.1	2.9	18.9
Policy variables				
Spending per pupil (SEK)	96,555	10,220	72,800	137,800
Pupils per teacher	12.6	2.4	1.6	42.1
Share of certified teachers (%)	72.1	20.5	0.0	100.0
Adaptation to pupil needs	6.9	0.6	4.5	8.8
Socio-economic variables				
Share of new immigrants (%)	4.4	6.4	0.0	51.0
Share of boys (%)	51.8	9.0	0.0	100.0
Parent education level (index)[a]	2.3	0.2	1.3	3.0
Competition				
Density	0.8	1.0	0.0	5.6

[a] Education level is based on both parents highest educational attainment and runs from 1 to 3.

pil achievement. It is often considered the most reliable among various measures of teacher quality [Darling-Hammond 2000]. The pupils-to-teacher ratio is the number of pupils divided by the number of full-time equivalent teachers at the school level. Adaptation to pupil needs is based on the School Inspectorate's Pupil Satisfaction Survey (*Skolenkäten*). The questionnaire contains a total of 14 items on the school climate, such as conditions for learning, physical safety and emotional support. Each survey question is given as a statement, and pupils are asked to assess whether this statement corresponds to their own experience on a four-point scale ranging from "corresponds completely" to "does not correspond at all". "I do not know" is included as a fifth option. These answers are translated into numerical scores of 10, 6.67, 3.33 and 0, respectively, and answers of "I do not know" are excluded. The variable used in our main analysis is the school-level score under item four, "Adaptation to the pupil's needs", which is the average of responses to three questions/statements ("I can get extra tutoring if I should need it", "My teachers help me with my school work when I need it" and "School work is difficult for me"). Consistency checks are carried out with the 13 other survey items. As the survey items are positively correlated at the 1% significance level, only one at a time is included in the regressions to avoid multicollinearity.

Differences in the socio-economic background of pupils are controlled for by the share of newly arrived migrants, and the education level of parents. The share of boys is also included to account for systematic differences in results between genders. The share of new immigrants is defined as the share of pupils who immigrated less than four years before completing compulsory education. The education level of parents is measured with an index where each parent is assigned a score of one if their highest-achieved level of education is at the lower secondary level or below, two if it is upper secondary education, and three if it is tertiary education. The index value is the parents' average education level, ranging from one to three. Dummies for the school owner (municipal, private for-profit and private non-profit) and for the functional labour market regions (LA-regions) centred on the three main agglomerations of Stockholm, Gothenburg and Malmö are added.[2]

The average policy settings and pupil characteristics vary across types of schools (Table 2). The average mathematics test score is highest in non-profit private schools, followed by for-profit schools. Spending per pupil is also somewhat higher in private than in public schools, reflecting differences in location, as municipalities are compelled to fund private and public schools equivalently. For-profit schools have a markedly lower share of certified teachers than other schools. Private schools are perceived to adapt education better to pupil needs, and non-profit schools even more so than for-profit schools. Private school pupils have on average more favourable socio-economic characteristics, with far fewer new immigrants, a lower share of boys, and parents with higher average education attainment. They are also more subject to competition as they are on average located in areas with a higher density of schools.

Empirical Analysis Methodology

The model estimates a production function of educational outcomes, using standard panel regressions, as well as panel stochastic frontier analysis. The basic model can be written as follows:

(1) $$y_{it} = \alpha + \mu_i + \gamma_t + \beta\, x_{it} + \delta w_i + \varepsilon_{it},$$

where y_{it} is the natural logarithm of average mathematics test result of school i in year t, α is a constant, μ_i are school effects, γ_t are year fixed effects accounting for the variation in average test scores over time, x_{it} is a matrix of time-varying variables, w_i is a matrix of time-invariant variables and ε_{it} are random errors.

The full model in equation (1) can only be estimated using random school effects, as it includes time-invariant variables. However, the

[2] Functional labour market regions are based on commuting patterns in the LA15 update from Statistics Sweden (2018b).

Table 2. **Averages by type of schools and tests for differences**

	Averages by group				
	Public	For-profit[a]		Non-profit[b]	
Dependent variable					
Mathematics test score	11.3	12.2	***	13.6	***/***
Policy variables					
Spending per pupil (SEK)	96,143	97,579	**	99,710	***/***
Pupils per teacher	12.3	14	***	12.3	/***
Share of certified teachers (%)	73.6	66.2	***	72.3	***/**
Adaptation to pupil needs	6.9	7.1	***	7.4	***/**
Socio-economic variables					
Share of new immigrants (%)	5.4	0.9	***	1.3	***/
Share of boys (%)	52.6	50	***	46.3	***/***
Parents' education (index)	2.2	2.4	***	2.5	***/***
Competition					
Density	0.7	1.0	***	1.5	***/***

Note: ***,** and * indicate significant difference between the means of two groups at the 1%, 5% and 10% level, respectively.

[a] The significance tests are conducted for the comparison with public schools.

[b] The significance test results are reported for comparisons with public schools (left) and for-profit schools (right).

random effect (RE) model assumes the absence of correlation between the school effects and the regressors, an assumption which may not hold, in which case the RE coefficients would be biased and inconsistent. In that case, the fixed effects (FE) model would yield unbiased estimators, but it also has significant drawbacks. First, it does not allow the inclusion of time-invariant regressors, in particular the variable measuring the adaptation of education to pupil needs, for which only one point in time is available. Second, the FE model simply ignores cross-sectional information. In a sample where the number of schools is far larger than the number of years, this is likely to result in a huge loss of information. Finally, while the FE model yields unbiased and consistent estimates of the slope coefficients, it does not yield consistent estimates of the fixed effects, because of the incidental parameters problem (i. e. the number of parameters increases with the number of cross-sections). While this is a minor issue in traditional panel regressions, where the value of the fixed effect may be of limited interest, it has serious implications for the stochastic frontier analysis performed later in this paper, as it is bound to affect the efficiency estimates [Belotti et al. 2013]. Hence, in this paper we prefer the RE model, despite its potential statistical limitations.

The competition indicator constructed to test the relationship between school competition and results in this article follows a similar logic as Wondratscheck et al. [2013] and Misra et al. [2012], although contrary to the latter, we do not take into account the size of schools, as there is no clear rationale for assuming that larger schools are more attractive than smaller ones in general. Parents in Sweden are allowed to freely choose the school in which to place their children. Among municipal schools the choice is limited to the schools within the municipality of residence, while attendance at private schools is not limited by municipal borders. The indicator is therefore constructed such that competition for private schools comes not only from the same municipality but also from neighbouring municipalities in border areas. Therefore, for private schools, competing schools can be any type of school (i. e. private or public) within a specified travel time. For public schools, competition comes from public schools in the same municipality and private schools within the specified travel time. Travel times between any pair of schools within our dataset are retrieved using the STATA user-written syntax '*georoute*'.[3] Travel time refers to the time to drive the distance under normal traffic conditions. The main indicator, the "density" indicator of competition, is constructed by simply counting the number of competing schools within a 15-minute radius. An alternative indicator, the "distance" competition indicator was calculated in a gravity-inspired framework.

To evaluate the efficiency of Swedish schools, we perform panel stochastic frontier analysis (SFA), which measures inefficiency as a distance to a production frontier. As schools can only be located below the frontier, the error term is skewed. Hence, equation (1) can be modified as follows:

$$y_{it} = \alpha + \mu_i + \gamma_t + \beta x_{it} + \delta w_i + v_{it} - u_{it}, \quad (2)$$

where v_{it} is a normally distributed random error and u_{it} is a positive or nil inefficiency term. u_{it} is assumed to follow an exponential distribution, but a robustness check is carried out assuming a half-normal distribution.

Several variants of the SFA model described in equation (2) have been proposed in the literature. In this article, the "true" random effects variant [Greene 2005] is used. Its main advantages are to allow time-variation in inefficiency, without imposing a deterministic structure on its time path, and to better separate inefficiency from time-invariant heterogeneity than earlier models.

[3] For more detail, see Weber and Péclat [2017].

Ordinary Panel Regressions

We start with an ordinary panel regression of mathematics test scores on school type, socio-economic and policy variables, indicators for the three largest municipalities and the density-based competition indicator, including random school effects and time fixed effects on the full school sample (Table 3, first column). The density-based competition indicator is close to zero and not statistically significant. As expected, parents' education has a strong positive influence on test scores, while the share of new immigrants and to a lesser extent the share of boys have a negative impact. The strong impact of socio-economic variables on school results is in line with the literature [Björklund, Salvanes 2011; Smidova 2019]. Average test scores are higher in the big municipalities, notably Stockholm, than in the rest of the country. Spending per pupil, the share of certified teachers and the adaptation to pupils needs are all significant at the 1% level, with the expected positive signs. Conversely, the number of pupils per teacher is statistically insignificant. When controlling for these factors, non-profit schools do not differ from public schools, but for-profit schools have lower results.

Next, we run the same regression on two sub-samples of schools, corresponding to the bottom and top quartiles of the school distribution, sorted on an indicator of the socio-economic characteristics of their pupils.[4] This allows us to assess whether competition has a different impact across groups of pupils. The competition indicator is associated with weaker results in the bottom part of the distribution, while there is no such effect in stronger schools. In addition, both the share of certified teachers and spending per pupil are significantly correlated with school results in the bottom quartile, but not in the top quartile, suggesting that these inputs matter more for disadvantaged schools. Other interesting results emerge from these regressions. While the coefficient of adaptation of education to pupil needs is significant in all samples, its magnitude is greater for schools where pupils come from less favourable socio-economic backgrounds. For-profit schools achieve significantly lower average scores than public schools at the 10% significance level in the bottom quartile, but not statistically different results in the top quartile. Non-profit private schools have better results than public schools in the bottom socio-economic quartile, but not in the top quartile. The share of new immigrants has a significant negative effect both in the top and bottom quartiles, although somewhat stronger in the bottom. Finally, results in Stockholm, Goth-

[4] The indicator is constructed by predicting counterfactual national mathematics test scores using the regression coefficients of the socio-economic variables. All other variables in the equation are assumed to take a constant value, equal for all schools. The schools are thus ranked according to the predicted test scores assuming the only difference between them is the share of newly arrived migrants, the share of boys and the parental education level.

Table 3. **Ordinary panel regressions**

	FULL-sample	Sub-sample	
		Bottom quartile	Top quartile
Policy variables			
Spending per pupil	0.091***	0.180**	0.0468
Pupils per teacher	0.000	-0.000	0.002
Share of certified teachers	0.080***	0.112***	0.022
Adaptation to pupil needs	0.050***	0.056***	0.035***
School type			
For-profit	-0.028***	-0.049*	-0.012
Non-profit	0.006	0.191**	0.006
Socio-economic variables			
Share of new immigrants	-0.308***	-0.407***	-0.263**
Share of boys	-0.060**	-0.146**	-0.048*
Parents' education	0.442***	0.461***	0.391***
Municipality			
Stockholm	0.050***	0.008	0.079***
Gothenburg	0.026***	0.015	0.041***
Malmö	0.035***	0.022	0.051***
Competition			
Density	-0.005	-0.025**	0.002
Constant	0.077	-0.951	0.797*
R^2 Overall	0.521	0.330	0.416
R^2 Within	0.287	0.316	0.247
R^2 Between	0.598	0.263	0.428

Note: Year fixed effects are included in all regressions. The total number of observations is 4878 for the full-sample regressions, representing 1140 schools. ***,** and * indicate significance at respectively the 1%, 5% and 10% level. Robust standard errors (clustered) are used. Quartiles are calculated after sorting schools according to the socio-economic characteristics of their pupils.

enburg and Malmö are not significantly different from the rest of the sample in the bottom quartile, but higher in the top quartile, suggesting some polarisation in these cities.

Stochastic Frontier Analysis

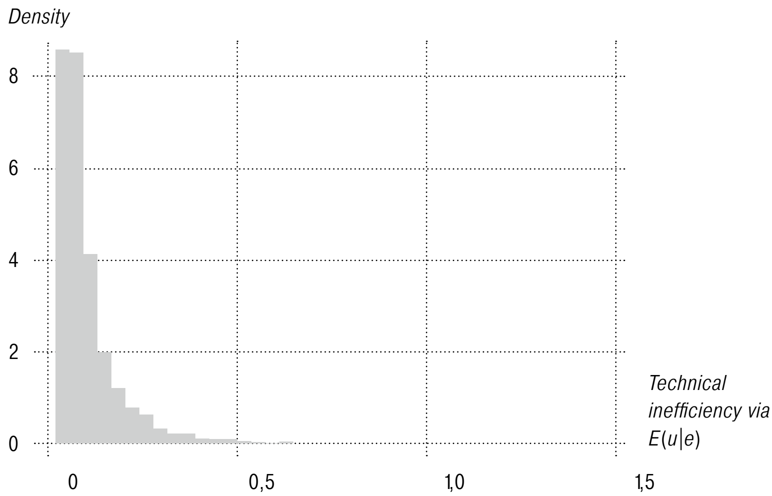
The results of our equation with all variables estimated using the "true" random effect SFA model with an exponential distribution of inefficien-

Table 4. **Stochastic frontier analysis**

	SFA	
Model type	Exponential	Half-normal
Policy variables		
Spending per pupil	0.063***	0.074***
Pupils per teacher	-0.001	-0.001
Share of certified teachers	0.046***	0.053***
Adaptation to pupil needs	0.040***	0.042***
School type		
For-profit	-0.000	-0.006
Non-profit	0.024	0.023
Year		
2014	-0.070***	-0.069***
2015	-0.104***	-0.106***
2016	-0.020***	-0.019***
2017	-0.111***	-0.115***
Municipality		
Stockholm	0.048***	0.049***
Gothenburg	0.027***	0.027***
Malmö	0.039***	0.039***
Socio-economic variables		
Share of new immigrants	-0.247***	-0.250***
Share of boys	-0.049**	-0.049**
Parents' education	0.371***	0.382***
Competition		
Density	-0.002	-0.004
Constant	0.737***	0.606**
Lambda[a]	1.79***	3.97***
Average inefficiency (%)	9.2	12.3
Sample		
Observations	4878	4878
Schools	1140	1140

Note: ***,** and * indicate significance at respectively the 1%, 5% and 10% level. Robust standard errors (clustered) are used.
[a] Lambda is the ratio of the variances of the asymmetric and symmetric errors.

Figure 1. **Distribution of inefficiency scores**



Source: Authors' calculations.As the literature points out that similar average levels of inefficiency may hide important variations in individual school efficiency scores and rankings [Greene 2005], we checked correlations and rank (Spearman) correlations between the efficiency scores from the two SFA models. They are above 95%, indicating that the models yield very similar individual school scores and rankings.

cy are displayed in the first column of Table 4. The results are qualitatively similar to the ordinary panel model results shown in the first column of Table 3, despite some differences in the magnitude of coefficients. The only difference in coefficient statistical significance relates for-profit schools, which are found to perform below average in the ordinary panel regression, but not significantly so in the SFA model. This presumably reflects the limited role these schools play in shaping the efficiency frontier. In SFA, their weaker performance is rather reflected in higher inefficiency scores.[5]

The lambda coefficient, which is the ratio of the variances of the asymmetric and symmetric errors, is significantly different from zero at the 1% confidence level, indicating that inefficiencies are present and validating the use of a SFA model. Average inefficiency is slightly above 9% and the distribution of efficiency scores is fairly narrow (Figure 1). Only about a tenth of inefficiency scores are above 20%, which is a relatively moderate share in statistical terms. For comparison, the standard deviation of test scores is about 18% of the mean. Nonethe-

[5] The average inefficiency scores are 10.7% for for-profit schools, 9.9% for public schools and 8.6% for non-profit schools.

less, low efficiency can have severe consequences for the pupils attending inefficient schools. As SFA estimates may be sensitive to the assumption on the distribution of the inefficiency term, we replicate the estimation assuming a half-normal instead of an exponential distribution (Table 4, second column). The results are very close, even though the level of inefficiency is somewhat higher under the half-normal assumption (approximately 12%).

Robustness Checks

To check the robustness of the results, we run a range of additional regressions.[6] First, to verify the stability of the coefficients, we estimate the main equation (Table 3, first column) without policy variables and with only one policy variable at a time. The coefficients are very close to those of the equation including all variables. It is worth noting, however, that when the share of certified teachers is omitted, private schools, particularly for-profit ones, seem to perform slightly worse. This is because these schools have a below-average share of certified teachers, as can be seen from Table 2. Conversely, when the adaptation to pupils needs variable is omitted, the performance of private schools appears to increase somewhat, because private schools (both for-profit and non-profit) score better than public schools on this variable. Both the share of certified teachers and the adaptation to pupil needs are, to some extent, under the control of schools, calling for caution in the interpretation of the school-type coefficients. Moreover, average results mask wide variation across schools.[7] Second, the indicator variables for the three main cities are replaced by fixed effects for all municipalities. This allows checking that uncontrolled heterogeneity across municipalities is not biasing our results. The coefficients are roughly unchanged for most variables. Third, we use alternative measures of competition. We replace the school density indicator by the share of pupils attending private schools, in the spirit of Böhlmark and Lindahl [2015]. The results are similar to those found with the density indicator, except that negative competition effects are also significant for the full-sample regression. Then, we use the distance indicator of competition, which yields similar results as the density indicator. Fourth, we replace the measure of adaptation of education to pupil needs by other survey measures of school organisation, basic values and learning environment, which barely alters the results.

---

6 To save space the results are not shown, but are available from the authors on request.

7 When the equation in the first column of Table 3 is estimated including five dummies for separate groups of private schools, independent or belonging to different companies, instead of a single dummy representing all for-profit schools, the coefficient of these dummies range from –0.035 (significant at the 5% level) to +0.115 (significant at the 1% level). This illustrate the heterogeneity among for-profit schools.

Discussion

School competition is negatively associated with results in schools with the least favourable socio-economic mix of pupils, although only weakly. This result is consistent with findings from Yang Hansen and Gustafsson [2016] and Böhlmark et al. [2016], but opposite to the results found by Wondratschek et al. [2013], Edmark et al. [2014] and Böhlmark and Lindahl [2015]. However, these studies analysed older data, ending between 2006 and 2009. A possible interpretation of differences in results is thus that the effects from competition have changed over time. Research shows that the impact of school choice on educational performance varies across countries, depending in particular on framework conditions and implementation, school autonomy and policy guidance. The ability of the education system to provide real, relevant and meaningful choice is also essential to ensure equity and narrow between-school variation in performance [OECD2017]. Pupils from more favourable backgrounds utilise school choice to sort into higher-performing schools, while school choice is less utilised by pupils from less favourable backgrounds. Lower-achieving pupils in Sweden lose more than higher-achievers gain from school and classroom segregation [Sund 2009]. These asymmetric peer effects combined with increasing school segregation could turn the previous positive effect from school competition negative. This would be consistent with some results found in the United States [Akyol 2016] and Chile [Hsieh, Urquiola 2006; Elacqua 2012], even though one needs to keep in mind differences in the education systems and socio-economic conditions between these countries and Sweden.

The lower performance of for-profit schools compared to public and non-profit schools, after controlling for other factors, calls for further investigation. This result is strongest in schools catering to lower socio-economic groups. Private schools are perceived as adapting education better to pupils' needs on average, which calls for a cautious interpretation. As controls for the socio-economic background of pupils at the school level are relatively crude, one cannot rule out that lower performance results from a higher level of pupil disadvantage. An analysis at the pupil level would be needed to reach firmer conclusions on the relative performance of for-profit schools.

The average level of inefficiency is about 10%, implying that schools could increase their average mathematics test score by on average 10% for a given level of inputs. The distribution is relatively narrow. Less than a tenth of inefficiency scores are greater than one standard deviation in test scores. Even though relatively few schools have low efficiency, the consequences for their pupils can be serious, and low scores imply a potential to improve results by moving closer to the efficient frontier. As efficiency scores depend on modelling assumptions, notably regarding time variation in efficiency [Greene 2005], they should be interpreted with caution. Nevertheless, the analysis suggests that while some Swedish schools could achieve efficiency gains, few are very far from the efficiency frontier when educational inputs and pupil socio-economic characteristics are taken into account.

Altogether, our results suggest that improving educational results requires better targeting resources towards supporting the pupils most in need and steering competition and school choice so that they benefit pupils from all socio-economic groups equally.

References

Akyol M. (2016) Do Educational Vouchers Reduce Inequality and Inefficiency in Education? *Economics of Education Review*, vol. 55, iss. C, pp. 149–167. https://doi.org/10.1016/j.econedurev.2016.10.001

Belotti F. et al. (2013) Stochastic Frontier Analysis Using Stata. *The Stata Journal*, vol. 13, no 4, pp. 719–758. Available at: https://www.stata-journal.com/article.html?article=st0315 (accessed 10 August 2020).

Borland M. V., Howsen R. M. (1992) Student Academic Achievement and the Degree of Market Concentration in Education. *Economics of Education Review*, vol. 11, no 1, pp. 31–39. https://doi.org/10.1016/0272–7757(92)90019-Y

Björklund A., Salvanes K. (2011) Education and Family Background: Mechanisms and Policies. *Handbook of the Economics of Education* (eds E. Hanushek, S. Machin, L. Woessmann), North Holland: Elsevier, vol. 3, pp. 201–247.

Blair J. P., Staley S. (1995) Quality Competition and Public Schools: Further Evidence. *Economics of Education Review*, vol. 14, no 2, pp. 193–198. https://doi.org/10.1016/0272–7757(95)90398-R

Böhlmark A., Lindahl M. (2015) Independent Schools and Long Run Educational Outcomes: Evidence from Sweden's Large-Scale Voucher Reform. *Economica*, vol. 82, no 327, pp. 508–551. http://dx.doi.org/10.1111/ecca.12130

Böhlmark A., Holmlund H., Lindahl M. (2016) Parental Choice, Neighbourhood Segregation or Cream Skimming? An Analysis of School Segregation after a Generalized Choice Reform. *Journal of Population Economics*, vol. 29, no 4, pp. 1155–1190. https://doi.org/10.1007/s00148–016–0595-y

Conroy S. J., Arguea N. M. (2008) An Estimation of Technical Efficiency for Florida Public Elementary Schools. *Economics of Education Review*, vol. 27, no 6, pp. 655–663. https://doi.org/10.1016/j.econedurev.2007.08.002

Dancer D., Blackburn V. (2017) What Are the Effective Public Schools? Insights from New South Wales' Secondary Schools Using a Stochastic Frontier Analysis with a Panel Dataset. *Australian Journal of Education*, vol. 61, no 2, pp. 141–163. https://doi.org/10.1177/0004944117713555

Darling-Hammond L. (2000) Teacher Quality and Student Achievement: A Review of State Policy Evidence. *Education Policy Analysis Archives*, vol. 8, no 1. https://doi.org/10.14507/epaa.v8n1.2000

Dee T. S. (1998) Competition and the Quality of Public Schools. *Economics of Education Review*, vol. 17, no 4, pp. 419–427. https://doi.org/10.1016/S0272–7757(97)00040-X

Edmark K., Frölich M., Wondratschek V. (2014) Sweden's School Choice Reform and Equality of Opportunity. *Labour Economics*, vol. 30, October, pp. 129–142. https://doi.org/10.1016/j.labeco.2014.04.008

Elacqua G. (2012) The Impact of School Choice and Public Policy on Segregation: Evidence from Chile. *International Journal of Educational Development*, vol. 32, no 3, pp. 444–453. https://doi.org/10.1016/j.ijedudev.2011.08.003

Greene W. (2005) Reconsidering Heterogeneity in Panel Data Estimators of the Stochastic Frontier Model. *Journal of Econometrics*, vol. 126, no 2, pp. 269–303. http://dx.doi.org/10.1016/j.jeconom.2004.05.003

Gustafsson J., Sörlin S., Vlachos J. (2016) *Policyidéer för svensk skola* [Policy Ideas for Swedish Schools]. Stockholm: SNS. Available at: https://www.sns.se/wp-content/uploads/2016/07/policyideer_for_svensk_skola.pdf (accessed 10 August 2020).

Heller Sahlgren G. (2011) Schooling for Money: Swedish Education Reform and the Role of the Profit Motive. *Economic Affairs*, vol. 31, no 3, pp. 28–35. Available at: http://hdl.handle.net/10.1111/j.1468–0270.2011.02112.x (accessed 10 August 2020).

Heshmati A., Kumbhakar S. C. (1997) Efficiency of the Primary and Secondary Schools in Sweden. *Scandinavian Journal of Educational Research*, vol. 41, no 1, pp. 33–51. http://dx.doi.org/10.1080/0031383970410103

Hinnerich B. T., Vlachos J. (2017) The Impact of Upper-Secondary Voucher School Attendance on Student Achievement. Swedish Evidence Using External and Internal Evaluations. *Labour Economics*, vol. 47, pp. 1–14. https://doi.org/10.1016/j.labeco.2017.03.009

Holmberg J. (2017) *The Relative Efficiency of Swedish Secondary Schools. An Estimation Using Stochastic Frontier Analysis* (Master thesis). Umeå: Umeå University. Available at: http://urn.kb.se/resolve?urn=urn%3Anbn%3Ase%3Aumu%3Adiva-137601 (accessed 10 August 2020).

Hsieh C-T., Urquiola M. (2006) The Effects of Generalized School Choice on Achievement and Stratification: Evidence from Chile's Voucher Program. *Journal of Public Economics*, vol. 90, no 8–9, pp. 1477–1503. https://doi.org/10.1016/j.jpubeco.2005.11.002

Kirjavainen T. (2012) Efficiency of Finnish General Upper Secondary Schools: An Application of Stochastic Frontier Analysis with Panel Data. *Education Economics*, vol. 20, no 4, pp. 343–364. https://doi.org/10.1080/09645292.2010.510862

Millimet D. L., Collier T. (2008) Efficiency in Public Schools: Does Competition Matter? *Journal of Econometrics*, vol. 145, no 1–2, pp. 134–157. https://doi.org/10.1016/j.jeconom.2008.05.001

Misra K., Grimes P., Rogers K. (2012) Does Competition Improve Public School Efficiency? A Spatial Analysis. *Economics of Education Review*, vol. 31, no 6, pp. 1177–1190. http://dx.doi.org/10.1016/j.econedurev.2012.08.001

Navarro-Palau P. (2017) Effects of Differentiated School Vouchers: Evidence from a Policy Change and Date of Birth Cutoffs. *Economics of Education Review,* vol. 58, iss. C, pp. 86–107. https://doi.org/10.1016/j.econedurev.2017.03.008

OECD (2019) *PISA 2018 Results. Combined Executive Summaries*. Vol. I, II, III. Paris: OECD. Available at: https://www.oecd.org/pisa/Combined_Executive_Summaries_PISA_2018.pdf (accessed 10 August 2020).

OECD (2017) *School Choice and School Vouchers: An OECD Perspective*. Paris: OECD. Available at: http://www.oecd.org/education/School-choice-and-school-vouchers-an-OECD-perspective.pdf (accessed 10 August 2020).

OECD (2015) *Improving Schools in Sweden: An OECD Perspective*. Paris: OECD. Available at: http://www.oecd.org/education/school/Improving-Schools-in-Sweden.pdf (accessed 10 August 2020).

Pareliussen J., André C., Hwang H. (2019) *Improving School Results and Equity in Compulsory Education in Sweden. OECD Economics Department Working Paper No 1587.* Paris: OECD. https://doi.org/10.1787/99a20fbe-en

Pereira M. C., Moreira S. (2007) *A Stochastic Frontier Analysis of Secondary Education Output in Portugal. Bank of Portugal Working Paper No 6–2007*. Available at: https://www.bportugal.pt/sites/default/files/anexos/papers/wp200706.pdf (accessed 10 August 2020).

Sandström F. M., Bergström F. (2005) School Vouchers in Practice: Competition Will not Hurt You. *Journal of Public Economics*, vol. 89, no 2–3, pp. 351–380. https://doi.org/10.1016/j.jpubeco.2004.03.004

Smidova Z. (2019) *Educational Outcomes: A Literature Review of Policy Drivers from a Macroeconomic Perspective. OECD Economics Department Working Paper No 1577*. Paris: OECD. https://doi.org/10.1787/990801aa-en

Statistics Sweden (2018a) *Djupdykning i statistik om Sveriges kommuner* [Deep-Dive in Statistics about Sweden's Municipalities]. Available at: https://www.scb.se/hitta-statistik/sverige-i-siffror/djupdykning-i-kommunstatistik/ (accessed 10 August 2020).

Statistics Sweden (2018b) *Lokala arbetsmarknader* [Local Labour Market Regions] Available at: https://www.scb.se/hitta-statistik/statistik-efter-amne/arbetsmarknad/sysselsattning-forvarvsarbete-och-arbetstider/registerbaserad-arbetsmarknadsstatistik-rams/produktrelaterat/Fordjupad-information/lokala-arbetsmarknader-la/ (accessed 10 August 2020).

Sund K. (2009) Estimating Peer Effects in Swedish High School Using School, Teacher, and Student Fixed Effects. *Economics of Education Review*, vol. 28, no 3, pp. 329–336. https://doi.org/10.1016/j.econedurev.2008.04.003

Sutherland D., Price R. W., Joumard I., Nicq C. (2007) *Performance Indicators for Public Spending Efficiency in Primary and Secondary Education. OECD Economics Department Working Paper No 546*. Paris: OECD. http://dx.doi.org/10.1787/285006168603

Swedish National Agency for Education (2018a) *Analyser av familjebakgrundens betydelse för skolresultaten och skillnader mellan skolor* (Analyses of Family Backgrounds Influence of School Results and Differences between Schools). Available at: https://www.skolverket.se/sitevision/proxy/publikationer/svid12_5dfee44715d35a5cdfa2899/55935574/wtpub/ws/skolbok/wpubext/trycksak/Blob/pdf3927.pdf?k=3927 (accessed 10 August 2020).

Swedish National Agency for Education (2018b) *SIRIS/SALSA Database*. Available at: https://www.skolverket.se/skolutveckling/statistik/sok-statistik-om-forskola-skola-och-vuxenutbildning (accessed 10 August 2020).

Swedish School Commission (2017) *Samling för skolan □ Nationell strategi för kunskap och likvärdighet* [Together for Schools—National Strategy for Knowledge and Equality]. Available at: http://www.regeringen.se/498092/contentassets/e94a1c61289142bfbcfdf54a44377507/samling-for-skolan---nationell-strategi-for-kunskap-och-likvardighet-sou-201735.pdf (accessed 10 August 2020).

Swedish School Inspectorate (2018) *Statistik från Skolenkäten* [Statistics from the Student Satisfaction Survey]. Available at: https://www.skolinspektionen.se/sv/Statistik/statistik-fran-skolenkaten/ (accessed 10 August 2020).

Swedish School Inspectorate (2013) *Olikheterna är för stora, Omrättning av nationella prov i grundskolan och gymnasieskolan* [Differences Are Too Big, Re-grading of National Tests in Compulsory and Upper Secondary Schools, 2013]. Available at: https://www.skolinspektionen.se/globalassets/publikationssok/granskningsrapporter/omrattning/2013/omrattning-nationella-prov-2013.pdf (accessed 10 August 2020).

Vlachos J. (2018) *Trust-Based Evaluation in a Market-Oriented School System. IFN Working Paper No 1217*. Stockholm: Institutet för Näringslivsforskning (IFN). Available at: https://www.ifn.se/publikationer/working_papers/2018/1217 (accessed 10 August 2020).

Weber S., Péclat M. (2017) A Simple Command to Calculate Travel Distance and Travel Time. *The Stata Journal*, vol. 17, no 4, pp. 962–971. https://doi.org/10.1177/1536867X1801700411

Wondratschek V., Edmark K., Frölich M. (2013) The Short- and Long-Term Effects of School Choice on Student Outcomes—Evidence from a School Choice Reform in Sweden. *Annals of Economics and Statistics*, vol. 111/112, Special issue on education, pp. 71–101. Available at: https://www.jstor.

org/stable/pdf/23646327.pdf?refreqid=excelsior%3Aa335cb8a84f37e-0896b58a9b1018c305 (accessed 10 August 2020).

Yang Hansen K., Gustafsson J. (2016) Causes of Educational Segregation in Sweden—School Choice or Residential Segregation. *Educational Research and Evaluation*, vol. 22, no 1–2, pp. 23–44. http://dx.doi.org/10.1080/13803611.2016.1178589