FUNDACION PARA LA EDUCACION SUPERIOR Y EL DESARROLLO

EFFICIENCY OF COLOMBIAN SCHOOLS

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(This version: September 22, 2003)

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1.   Introduction

The main goal of this paper is to study the efficiency of Colombian schools with an eye on understanding what drives school productivity and how much is to be gained by increasing efficiency. The paper uses Data Envelopment Analysis (DEA) to study efficiency and a Tobit model to study the determinants of efficiency.

This is not the first paper to look at the efficiency of secondary schools in Colombia. Gaviria and Barrientos (2001) look at the determinants of test scores in the city of Bogotá. They find that public schools produce lower scores than private schools after controlling for socioeconomic characteristics. More importantly, they find that teachers' education and infrastructure positively affect scores in private schools but not in public schools, which suggests the existence of inefficiencies in publicly provided education. Nunez *et al.* (2002) look at the differences between private and public secondary schools in both urban and rural areas for the year 1999. They find that public schools produce, on average, lower scores. However, at the bottom of the distribution, public schools appear to be better than private schools. Finally, Barrera (2003) finds that test scores in both public and private schools increased in the last decade, but that private school scores increased more than public school ones.

Initially for the investigation, we analyzed the case of Bogotá. However, given the disparity between this city and the rest of the country and a desire to include municipal level variation, we decided to expand the study to the national level. The results, as we will show, change dramatically in the two samples. We will, therefore, present the results using the national sample and analyze the specific case of Bogotá separately.

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The paper has the following structure. In the second part, we describe the main methodology used in the analysis. The third part presents the results for the whole country. The next section includes a discussion of the potential role of costs of public versus private education. Finally we close the paper with some general conclusions. In the Appendix we present the analysis of Bogotá as a particular case.

2.   Description of methodology

This section describes the methodology used in the paper. The analysis consists of three steps. First, Data Envelopment Analysis (DEA) is used to compute the relative efficiency, or efficiency score, of schools. Then a Tobit regression is used to study the determinants of school efficiency scores in Colombia. Special attention is paid to the differences of private versus public schools in Colombia. Finally, we use indirect evidence, based mainly on household data, to get a sense of the cost differentials between private and public schools.

As customary in this literature[2], we assume that schools produce a set of outputs (e.g., standardized test scores) by using a set of inputs (e.g., number of teachers and mean schooling). As a rule, factors that can be influenced by the schools are included in the DEA models, whereas factors beyond the scope of decision making power of schools are included in the analysis of the determinants of efficiency. The first type of factors includes teacher's education and teacher-pupil rations and the second type includes student's socioeconomic attributes, and whether the school is public.

DEA is a non-parametric method that uses the information about the levels of inputs and outputs used by each school to (i) determine a frontier of efficiency and (ii) to compute how far from this frontier any single observation is located. Observations under the frontier are inefficient in that it is possible either to reduce the use of inputs to achieve the same level of output or to increase the production of output with the same amount of inputs. It bears stressing that the frontier is build from the most efficient observations in the *sample*. Therefore, the estimated frontier does not necessarily coincide with the true production frontier.

In this paper, we use an input-oriented distance function to compute the extent of inefficiency (i.e., how far is a school from the frontier). Simply put, input-oriented distances are computed as the ratio of the quantity an efficient school would have used to produce a unit of output to the actual quantity used by the school in question. Thus, if an efficient school uses two units of a given input to produce two units of output, and the school being evaluated uses four units of

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[2] For a good review of the literature on DEA analysis and education, see Lovell, Walters and Wood (1994).

the same input to produce the same two units of the output, it will have a technical efficiency of 50%. The same simple logic could be generalized for the case in which there are various inputs and outputs.

A linear program is used to compute the efficiency scores for each school in the sample. Assuming constant returns to scale (CRS) and considering that only one output is being produced, the general form of the programs is as follows:

$$\max_{u,v} g_o = \frac{uy_o}{\sum_{i=1}^{m} v_i x_{i0}}$$

subject to,

$$\frac{uy_j}{\sum_{i=1}^{m} v_i x_{ij}} \leq 1, j = 1,...,n$$

$$\sum_{i=1}^{m} v_i x_{i0} = 1$$

$$u, v_i > 0$$

where the subscripts i and j are used to identify the inputs and the schools, the variables y_0 and x_0 denote the output and inputs of the school being evaluated, g_0 denotes the corresponding efficiency score, y_j the observed output for school j, x_{ij} the observed level of inputs. Finally, u and v_j are the weights determined by the solution of the program.

The literature offers many thorough depictions of the technical aspects of this methodology. To understand the basic intuition, it suffices to focus on the objective function and the first constraint. The program consists of choosing u and v_j so as to maximize the efficiency score of school 0 subject to the constraint that the efficiency score of no other school exceeds one. Because this program doesn't have a unique solution, the second normalizing constraint is added. The non-negativity constraints guarantee that output cannot be lowered by increasing inputs.

The assumption of CRS can be relaxed by introducing a new variable in the numerator of both the objective function and the first constraint. That is,

$$\max_{u,v} z_o = \frac{uy_o + u_0}{\sum_{i=1}^{m} v_i x_{i0}}$$

subject to,

$$\frac{uy_j + u_o}{\sum_{i=1}^{m} v_i x_{ij}} \leq 1, j = 1,...,n$$

$$\sum_{i=1}^{m} v_i x_{i0} = 1$$

$$u, v_i > 0$$

where u_0 is the new variable and z_0 the efficiency scores under the assumption of variable returns to scale (VRS). A positive u_0 implies increasing returns to scale. A negative u_0 implies the opposite. In the empirical work, we first estimate efficiency scores assuming both constant and variable returns to scale and then compare the estimated values of g_0 and z_0.

In the second step of the analysis, we regress the efficiency scores on a set of average socioeconomic characteristics of the students and on dummy variable showing whether the school in question is public. Our goal is to shed some light on the determinants of school efficiency. From previous research on the topic, we gather that efficiency to be smaller in public schools and in schools that have a greater proportion of disadvantage students.

3. Efficiency and its determinants

a. Data

The data used in this paper come from two sources: (i) data on test scores and on socioeconomic characteristics of the students come from the Colombian Institute of Superior Education (ICFES) and (ii) data on school attributes, including indicators of teachers' education and school infrastructure come from the Colombia Bureau of Statistics (DANE). Test scores correspond to school means of the ICFES test, a test equivalent of the American SAT, taken by most Colombian student upon finishing high school and for all students aspiring to enter college and is used by most universities to screen candidates. Socioeconomic attributes are computed using a survey responded by students six months before the test.

School attributes are computed using a census of schools performed yearly by DANE. We include both private and public schools. Schools were fewer than six students took the test in 1999 were excluded from the sample. Although we attempt to include as many schools as possible, some have to be dropped of the sample because we couldn't merge the data on test scores and students characteristics with the data on school attributes.[3]

We exclude nine departments from the analysis, mainly because of sharp differences between them and the rest of the Colombian departments.[4] Overall, the sample includes 3.363 schools and around 230.000 students. Main summary statistics are presented in Table 1. Mean test scores at the national level are 244,72 points. Years of mean parental education are around 10 years, and the respectively statistic for teachers is close to 16 years. The teacher-pupil ratio is 0.06; the fraction of schools with computer facilities is 0.88. The percentage of schools with no libraries is 5%, with one library is 79% and with two or more libraries is 16%. The average school size is around 419 students (with a very high standard deviation). The percentage of schools that are public is 59%.

Table 1. Descriptive Statistics for the National Level		
Variable	Mean	Stand. Deviation
Mean Score	244,72	26,87
Mean Parental Schooling (years)	10,35	2,29
Mean Teacher Schooling (years)	15,96	1,19
Percentage of Parents with Professional Ocuppations	0,21	0,19
% Male Students	0,46	0,24
Teacher Pupil Ratio	0,06	0,03
Number of Students	418,72	299,86
Number of Teachers	21,32	12,93
Size of Graduating Class	78,46	67,91
Percentage of Schools with (at least one) Computer Rooms	0,88	
Percentage of Schools with (at least one) Library	0,95	
Percentage of Public Schools	0,59	
Percentage of Urban Schools	0,84	

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[3] Merging was is complicated because school identifications numbers do not coincide in both data sets. We use school names and phone numbers to circumvent this problem.
[4] They are the new created departments by the Constitution of 1990 (the majority of them located in the Amazon region), in addition of Choco, Putumayo and the main oil producer departments.

b. Estimates of School Efficiency at the national level

As mentioned earlier, we study differences in efficiency among schools by Data Envelopment Analysis (DEA).[5] First, we define the inputs and the outputs. As customary in the international literature[6], we use variables on teacher characteristics and school infrastructure to measure inputs and test scores to measure outputs. Because of the lack of a definitive criterion for selecting the number and type of variables to be included in the analysis, we run two different models. We compute efficiency scores for each model and examine the correlations among the scores. This strategy enables us to test the stability of the results.[7] Also, given the results obtained at different stages of the paper regarding the scale of returns in the production process, we limit the report to constant returns to scale.[8]

Table 2 describes the two models reported in the analysis. Model 1 uses five variables to measure inputs: teacher's education and teacher-pupil ratio (the main resources present in the classroom), computer facilities and infirmary (proxies to the amount of resources outside the classroom) and the number of students (included to capture scale effects). Model 2 uses two outputs (test scores and the number of students) and four inputs (the number and the mean schooling of teachers and dummies for the existence of computer facilities and infirmary). With respect to previous empirical findings regarding school production estimates, Gaviria (2002) shows that, on average, teacher's education, teacher-pupil ratios and school infrastructure are positively correlated with test scores. The correlation appears to be circumscribed to private schools, however.

Table 2. Variables used in DEA efficiency measurements

	Model 1	Model 2
Inputs:		
Teacher Education	X	X
Teacher-Pupil Ratio	X	
Number of Teachers		X
Computer Room	X	X
Infirmary	X	X
Number of Students	X	
Outputs:		
Test scores	X	X
Number of Students		X

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[5] Kirjavainen and Loikkanen (1998) and Sengupta and Sfeir (1986) present studies following a similar methodology.

[6] Hanushek (1996) presents a general review of the literature on production of education.

[7] We present the result of two models. We also run an additional model that explores the inclusion of different inputs but the result does not change and thus are not presented here.

[8] The results when assuming constant returns to scale (CRS) and variable returns to scale (VRS) do not differ significantly, and therefore we limit the estimation to the CRS case.

Model 1 is one in which the final objective of the school is the production of test scores, which is a proxy for the "quality" of education given by the schools. Model 2 combines into the objective of the school test scores and the number of children attending the school. In other words, both "quality" and enrolment are important objectives of the school. This allows us to explore the differences in objectives of different types of schools. Presumably for the public sector enrolment is an important objective; whereas for the private ones, quality is a key objective.

Again, we perform two types of tests before we compute the DEA scores. On one hand, we run several regressions of test scores against the characteristics of the schools. On the other hand, based on these regressions we run a procedure to eliminated outliers from the sample.[9] Summary statistics of mean efficiency scores for schools in the sample are presented in Table 3. The minimum efficiency is 54% in the extreme case, average inefficiency is between 23 and 24 percent, and the percent of efficient schools is between 1.5% and 1.2%.

Table 3. Average Efficiency (CRS) and Descriptive Statistics

	Model 1	Model 2
Number of Schools	2571	2583
Mean	76,1%	77,2%
Minimun	53,8%	54,7%
Percentage of Efficient Schools	1,5%	1,2%

Note: All DEA estimation exclude two types of observations:
a) Outliers by the hadivrno prodecure and
b) Schools located in Amazonas, Putumayo, Caqueta, Vaupés, Guaviare, Guanía, Vichada, Casanare, Arauca and Choco

We proceed by running a Tobit model in order to detect factors that explain the efficiency of schools at the national level. Three sets of variables are used in the model as independent variables, all of them outside the schools' decision power. The first set of variables includes percentage of male population in the schools and the average income of the family attending the school. The second type of variable used is a dummy indicating whether or not the school is public. The last set of variables captures characteristics of the localities in which the school operates. The main idea is to look at whether or not municipal characteristics influence the efficiency of schools.

We analyzed several characteristics of the municipality. These can be grouped into policy variables and exogenous variables. Four policy variables were tested: total per capita investment in education by the municipality during 1994 and

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[9] We run a routine in Stata base on the filter of Hadi (1993). Again, the results are quite stable across different specifications, e.g. with and without outliers.

1999; investment in education as a percentage of total spending in 1994 and 1999; number of public libraries; and the presence of a "house of culture".[10] As exogenous variables we include six variables: the percent of schools that operate in the rural area of the municipality; the percent of population in the urban area; an index of quality of life in 1993; an index of unsatisfied basic necessities in 1993; whether the school is located in a capital of a department; and a fixed effects model by departments. Table 4 presents summary statistics of these variables.

Table 4. Descriptive Statistics for Municipal Information		
Variable	Mean	Stand. Deviation
Percentage of Urban Population 2000	0,41	0,22
Insatisfied Needs Index (NBI) 1993	49,98	16,29
Life Conditions Index (ICV) 1993	56,94	10,20
Total flow of public investment in education per capita between 1994 and 1999 (Thousands of 1999 pesos)	163,17	67,35
Public investment in education as a percentage of public investment between 1994 and 1999	0,25	0,04
Percentage of Capital Cities	0,48	
Percentage of municipalities with (at least one) Public Library	62,30	
Percentage of municipalities with (at least one) Cultural Facility (Casa de la Cultura)	26,60	

The results of the Tobit model are present in Tables 5a and 5b, which correspond to the estimations using efficiency scores of Model 1 and 2, respectively. Various conclusions can be draw from these estimations. With respect to the socioeconomic characteristics, the percentage of male students in the school and the educational level of the parents are positively and significantly correlated with the efficiency of schools, independent of the model used.

With respect to the type of school, public schools are systematically less efficient than private ones if the independent variable is the efficiency measure of Model 1. The relationship holds for all regressions and it is statistically significant. However, when the independent variable is the efficiency measure from Model 2, public schools are more efficient than private ones: public schools perform better than private ones when both the enrolment and test scores are taken as the objective of the school.

One striking result is the effect of the variable "urban schools," which is an indicator variable for a school in an urban area (Urban=1, rural=0), on the

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[10] Houses of culture are public institutions (literally, a house) in which cultural events are presented like art expositions and concerts, usually with the support of the municipality.

efficiency. For Model 1 in which the output is just test scores, rural schools are more efficient than urban ones. On the contrary for Model 2, in which enrolment and test scores are the outputs, the variable loses significance.

With respect to characteristics of localities, different results emerge depending on the model used. Public investment in education as a percentage of public investment (between 1994 and 1999) is not correlated with the efficiency of schools. In plain words, the relative size of the expenditure is not important. With respect to the total flow of public investment in education per capita between 1994 and 1999, the first results indicate a positive and significant correlation of the variable with efficiency. However, the picture changes dramatically when a departmental fixed effects model is estimated: controlling for other departmental characteristics, on average the total flow of public investment in education is negatively correlated with efficiency, independent of the specification used.

We estimated the national model with a dummy capturing the schools in Bogotá. The interaction of this dummy with the flow of public investment in education shows a positive correlation between this investment and efficiency of schools in Bogotá, whereas in the rest of the country the relationship is negative. In other words, the public investment in education in Bogotá induces a higher efficiency; the contrary applies to the rest of the country. Moreover, controlling by all these variables, there is not significant differences in the efficiency of public and private schools in Bogotá, independent of the model used. These results are confirmed by the in-depth analysis of Bogotá presented in the Appendix.

Finally, with respect to indices that capture poverty (Insatisfied Needs Index of 1993), the results indicate no relationship between them and efficiency of schools, regardless of the model used. One potential problem for both variables is that they are constructed using the 1993 census, and the data of schools is from the year 1999. It is not possible to construct more recent measures due to lack of representative data at the municipal level.

Table 5a. Determinants of Efficiency at the National Level (Tobit Model)

Dependent Variable: Model 1 (CRS) Efficiency Score

Variables	Simple Model	Models with local public policy variables					Fix Effects by Department	Fix effect, only Bogota
% Male Students	0,0243	0,0328	0,0269	0,3280	0,0333	0,0328	0,0351	0,0330
	3,65	4,40	3,87	4,41	4,50	4,41	4,86	4,46
Mean Parental Schooling (years)	0,0174	0,0182	0,0179	0,0180	0,0170	0,0179	0,0183	0,0178
	19,79	17,90	19,17	17,75	16,55	17,36	18,40	17,63
Jornada No 2	-0,0100	-0,0125	-0,0099	-0,0115	-0,0140	-0,0120	-0,0090	-0,0113
	-2,43	-2,19	-2,29	-2,02	-2,47	-2,07	-1,60	-1,99
Jornada No 3	-0,0131	-0,0172	-0,0142	-0,0167	-0,0210	-0,0175	-0,0142	-0,0168
	-2,88	-2,63	-2,82	-2,57	-3,21	-2,60	-2,16	-2,57
Public Schools	-0,0131	-0,0085	-0,0143	-0,0079	-0,0063	-0,0076	-0,0063	-0,0080
	-3,71	-2,08	-3,85	-1,92	-1,53	-1,81	-1,52	-1,75
Urban School	-0,0297	-0,0277	-0,0330	-0,0297	-0,0348	-0,0303	-0,0344	-0,0337
	-6,69	-3,98	-7,15	-4,25	-4,94	-4,26	-4,98	-4,82
Local Public Policy Variables								
Public investment in education as a percentage of public investment between 1994 and 1999		0,0085						
		0,33						
Public Libaries per 1000 inhabitans			0,0030					
			1,72					
Total flow of public investment in education per capita between 1994 and 1999 (Thousands of 1999 pesos)				0,00004	0,00002	0,00004	-0,00016	-0,00010
				2,84	1,70	2,67	-3,09	-3,13
Municipal Variables								
Insatisfied Needs Index (NBI) 1993					-0,0007			
					-4,38			
Capital City						0,002		
						0,4500		
Dummy Bogota X Public invest. in educ.								0,00012
								4,36
Dummy Bogota X Public School								0,002
								0,21
Constant	0,6162	0,6056	0,6136	0,6025	0,6409	0,6030	0,6409	0,6248
	54,64	38,60	50,78	42,30	38,51	42,22	37,64	41,36
Observations	2.571	1.561	2.327	1.561	1.561	1.561	1.561	1.530

t values under the coefficients

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Table 5b. Determinants of Efficiency at the National Level (Tobit Model)

Dependent Variable: Model 2 (CRS) Efficiency Score								
Variables	Simple Model	Models with local public policy variables					Fix Effects by Department	Fix effect, only Bogota
% Male Students	0,0180	0,0259	0,0199	0,0260	0,0264	0,0260	0,0290	0,0262
	2,90	3,57	3,07	3,60	3,70	3,61	4,20	3,66
Mean Parental Schooling (years)	0,0194	0,0193	0,0195	0,0190	0,0177	0,0188	0,0191	0,0187
	23,84	19,80	22,58	19,65	18,10	19,14	20,60	19,47
Jornada No 2	0,0068	0,0045	0,0064	0,0056	0,0021	0,0046	0,0064	0,0047
	1,78	0,81	1,54	1,03	0,39	0,83	1,19	0,87
Jornada No 3	0,0122	0,0069	0,0114	0,0074	0,0015	0,0059	0,0074	0,0057
	2,73	1,09	2,44	1,18	0,24	0,91	1,19	0,88
Public Schools	0,0292	0,0345	0,0302	0,0352	0,0376	0,0359	0,0384	0,0320
	8,92	8,64	8,70	8,87	9,55	8,89	9,68	7,24
Urban School	0,0052	0,0044	0,0027	0,0014	-0,0050	0,0002	-0,0024	-0,0035
	1,25	0,66	0,63	0,20	-0,08	0,03	-0,37	-0,53
Local Public Policy Variables								
Public investment in education as a percentage of public investment between 1994 and 1999		0,0284						
		1,15						
Public Libaries per 1000 inhabitans			-0,0016					
			-0,99					
Total flow of public investment in education per capita between 1994 and 1999 (Thousands of 1999 pesos)				0,00006	0,00004	0,00006	-0,00023	-0,00011
				4,35	2,79	4,03	-4,35	-3,27
Municipal Variables								
Insatisfied Needs Index (NBI) 1993					-0,0010			
					-6,03			
Capital City						0,004		
						0,9100		
Dummy Bogota X Public invest. in educ.								0,00012
								4,61
Dummy Bogota X Public School								0,015
								1,83
Constant	0,5384	0,5369	0,5389	0,5365	0,5876	0,5375	0,5944	0,5659
	51,43	35,35	48,02	39,09	36,76	39,07	36,78	39,03
Observations	2.583	1.562	2.333	1.562	1.561	1.562	1.562	1.536

t values under the coefficients

In conclusion, there is evidence of differences in the efficiencies of private and public schools in the nation as a whole. Public schools are relatively inefficient in producing test scores but they are relatively efficient producing test scores and enrolment of students. In terms of expenditures, on average the municipalities that invest more funds in education are more inefficient. Bogotá is the exception. Finally, the characteristics of the families are an important determinant of the efficiency of schools.

4.   The role of prices

The previous analysis considers only physical inputs. It can be argued, however, that the bulk of the inefficiencies of public schools has more to do with input prices than with the use of physical inputs. If inputs prices (notably salaries) are higher in public than in private schools, the difference could be much larger. The same point is made by Hoxby (2002) for the United States: "even if researchers were to find that public and private schools produce identical achievement, it would probably be true that private schools were considerably more productive (because they spend less on average)." This section looks at the differences in wages between private and public teacher with an eye in getting a sense of the differences in input costs between the two types of schools. Because salaries represent such a larger share of total education expenses and teacher-pupil ratios do not differ substantially between the two, the difference in costs will be closely associated with the differences in wages.[11] The next section will look at this conjecture in detail.

The current regulations of the teaching profession in Colombia have their origin in an educational statute (*Estatuto Docente*) promulgated in 1979. This statute specifies the norms that regulate the recruitment, labor stability, promotion, and retirement of teachers. The statute introduced a number of inefficiencies into public education. Most notably, teacher salaries are set by the central government, with little input from the regional agencies that end up paying the bill. Moreover, the directives (rectors) do not exercise any disciplinary control over the teachers. The *Estatuto Docente* orders that promotions be determined internally within the teaching profession, using a set of rules that are not always related to the teaching activities.[12]

The analysis is based on the September round of the 1999 Colombian household survey (ENH). This survey has national coverage and its representative for both the country as a whole and urban and rural areas taken separately. The survey

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[11] See Gaviria (2001) for a comparison of teacher-pupil ratios between private and public schools.
[12] See Acosta and Borjas (2002) for an in depth analysis of the institutions that regulate public education in Colombia.

allows for the identification of public workers and public and private teachers. A worker is a public school teacher if she reports an occupation of "teacher" in the ENH and works in the public sector. A worker is a private school teacher if she reports an occupation of teacher and works in the private sector.

Before studying the wage differentials between public and private teachers, a word about the recent evolution of the wages of public teachers is in order. Table 6 reports growth rate in teacher salaries between 1994 and 1999. Although the real teacher salary declined slightly in 1995, it rose considerably since then, at an annual rate of about 3 percent. To the extent that this pattern was circumscribed to public teachers, if could have caused sizable wage differentials between private and public teachers. Below we examine those differentials as of 1999.

Table 6	
Percent real growth of teacher's salaries in the public sector	
1995	-0.4
1996	2.9
1997	3.2
1998	6.3
1999	2.2
Source: Secretaría de Education Distrital.	

Table 7 presents descriptive statistics of the sample used in the analysis. On average, public teachers have 15 years of schooling, a level slightly above that of private teachers but well above that of a typical worker laboring in either the public or private sector. Public teachers have almost five years more of experience than private teachers and have salaries, at least, 15 percent higher. It remains to be seen, however, the extent to which this percentage shrinks once we control for teacher's experience and place of residence.

Table 7. Labor Market Characteristics

	Schooling	Experience	Male Worker	Monthly earnings
All workers	9,0	25,6	0,64	471593
	(4.8)	(13.0)		(643569)
Public employees*	9,7	26,8	0,62	596147
	(4.9)	(12.7)		(748604)
Public teachers	15,2	25,6	0,35	897521
	(2.4)	(9.5)		(937485)
Private teachers	14,7	20,8	0,32	767095
	(2.5)	(10.6)		(933956)

* It doesn't include teachers. Standard deviations in parentheses

Table 8 presents the estimation results of a series of Mincer equations. The dependent variable is the log of monthly wages. Independent variables include years of schooling, experience, experience squared as well as dummy variables identifying public workers and public and private teachers. Only individuals

who were employed at time of the survey were included in the sample. Column (1) shows that public teachers earn more than other workers with the same experience and education. The wage differentials between public teachers and non-teachers are close to eight percent.

Column (2) shows that public teachers do not earn higher wages than comparable public employees. If anything, public employees have slightly higher wages than public teachers. In contrast, column (3) shows that public school teachers earn much more than private school teachers: the wage differentials are close to 15 percent in this case.

Table 8. Teachers's wages: private *versus* public

	(1)	(2)	(3)
Years of Schooling	0,120	0,117	0,120
	(107.4)	(103.9)	(105.8)
Experience	0,053	0,052	0,053
	(44.3)	(43.0)	(44.4)
Experience^2	-0,0005	-0,0005	-0,0005
	(29.7)	(28.9)	(29.7)
Dummy male worker	0,188	0,191	0,187
	(20.9)	(21.3)	(20.7)
Dummy public teacher	0,084	0,144	0,079
	(4.1)	(6.9)	(3.8)
Dummy public employee		0,204	
		(17.7)	
Dummy private teacher			-0,059
			(2.2)
Number of observations	24624	24624	24624
R^2	0,394	0,401	0,394

All regressions include regional dummies.

Thus, if we take into account the differences in salaries between private and public teachers, efficiency differences between private and public schools can be much higher than previously estimated. If one assumes that public schools are, on average, less efficient than private schools (a result in line with the evidence of section 3 and the Appendix) and that public school teachers earn 15 more than comparable private schools teachers (a result in line with the evidence of this section), public schools will be, at least, 11 percent less efficient than private schools. Seemingly, a lot is to be gained by increasing efficiency in public schools.

Moreover, this difference can be higher if we take into account the differences in pensions benefits between public and private teachers. As Table 9 shows, the

pension benefits granted to teachers are extremely generous.[13] The table compares the pension benefits available to teachers with those established in Law 100 of 1993 (Law of Social Security Reform) for other workers in Colombia. A number of differences are worth noting. First, public teachers do not have to contribute to the funding of the system in order to receive a pension. In contrast, most non-teachers contribute 25% (of which 13.5% is obligatory). Second, teachers qualify to receive a special pension (*pensión de gracia*) at 50 years of age. Under the pay-as-you-go system set up by Law 100 of 1993 for non-teachers, the retirement age is 55 for women and 60 for men. Third, a different base salary is used to calculate the pension for teachers and non-teachers. The special pension is based on the basic monthly salary that the teacher had at the time of retirement, *including* bonuses and other benefits. In addition, the teacher's retirement pension is based on the average salary of the last year employed. In contrast, the pension benefits for non-teachers are based on the average salary in the last 10 years of the entire career if more than 1,250 weeks have been contributed. And finally, teachers typically receive 75 percent of the base salary, while non-teachers receive between 65 and 85 percent, depending on the number of weeks that the worker contributed to the system.

Table 9. Pension Benefit Regimes of the Magistery and Law 100 of 1993

Benefits	Special Pension [14] Pensión de Gracia	Retirement Pension [15]	Retirement Pension by old age	Law 100/93
Beneficiaries	National Teachers, nationalized and territorial, hired before 31-12-80[16]	National Teachers, Nationalized Teachers, Distritals, Departmental and Municipals[17].	Persons that reach the age of mandatory retirement and do not have own resources for their subsistence.	Affiliated with the pay-as-you-go system.
Time of Service	Typically 20 years	Typically 20 years	He/she is in active service with any time of	1000 weeks. Worker saves capital that

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[13] This discussion is taken from Acosta and Borjas (2002).

[14] The Nation is in charge of the Special Pension and it is recognized and paid by CAJANAL. The Law established that the Fondo de Pensiones Públicas-FOPEP should do it.

[15] The Nation is in charge of all Retirement Pension that began since the promulgation of Law 91 of 1989 (December 29) and will be paid by the Fondo Nacional de Prestaciones Sociales of the Magistery. But CAJANAL and the Fondo Nacional de Ahorros will be in charge if it is started before the date of promulgagion of that law.

[16] Law 91 of 1989. For the teachers who entered the system since January 1st of 1981, national and nationalized, and for those appointed since 1990, when they accomplished the legal requirements, only one retirement pension is recognized, equivalent to 75% of the monthly average salary of the last year.

[17] Workers Nacionalized, they are the teachers that enter the system by appointment of a territorial entity before January 1st of 1976 and those who entered since that date, according with the established by the Law 43 of 1975

			services.	generates at least one pension equal to 110% of the minimum salary.
Age	50 years, Men or Women	If hired after 1-1-90, 50 years for women, 55 years for men; if hired before 1-1-90, 50 years for men and women.	55 years old	55 years old women and 60 years old men
Contribution	Nation in charge.	Nation in charge	Nation in charge	13.5% until 4 minimum wages. 14.5% for 4 minimum wages and more. 75% paid by employer and 25% by worker
Base Salary for Calculating Pension Benefits	Basic monthly compensation, including bonuses and benefits	Average salary during the last year of service.	Last monthly salary earned.	Average salary in the last 10 years or in the whole work life if he/she has contributed more than 1250 weeks.
Pension Amount	75%	75%	20%, plus 25% for each year of service.	65% with 1.000 weeks of contribution, until 85% with 1.400 weeks. Individual Saving Depends on the capital accumulated on the individual saving account

Source: Acosta and Borjas (2002).

5. Conclusion

The analysis yields three main results. First, public schools are, on average, relatively inefficient in providing test scores but are relatively efficient providing test scores and enrolment. Second, given the input prices, public schools are relatively more inefficient than private ones. It can be argued that an important and critical objective of public education is universal coverage. Moreover, based

on the externalities of education and on capital market failures, the intervention of the State in terms of quantity of education is critical. However, the analysis shows that there is ample room for the improvement of public schools, both in terms of the quality and the cost of inputs.

The case of Bogotá, in comparison with the rest of the country, shows another important result. On average, increasing the share of investment in education results in inefficiency. Increased spending does not imply better efficiency in the production of test scores or in coverage. However, Bogotá differentiate itself from the rest of the country in this aspect: money matters in the production quality and quantity. Probably part of the "unexpected" result of insignificant differences in the efficiency of public and private schools in Bogotá depends on this factor. Bogotá is using the public investment in education in an efficient matter.

As conclusions we pose two non-competing hypotheses that explain this last result. First, the recent mayors of the District of Bogotá have improved in a substantial way the administration of education. Second, as show by the data, the number of public schools in Bogotá is lower than in the rest of the country. This can lead to an argument of competition: more competition from part of private schools induce more efficiency in public schools.

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Appendix: the case of Bogotá

a. Data

For the case of Bogotá, our sample includes 707 schools and almost 50.000 students. Table 1 presents summary statistics of the main variables used in the analysis. Mean test scores are around 260 points over a theoretical maximum of 400 points. Parental schooling is slightly above ten years, whereas teachers' schooling is above 15 years. The teacher-pupil ratio is 0.06, the fraction of schools with computer facilities 0.84 and the fraction with infirmary 0.34. Average school size is about 700 hundred students, although the standard deviation is very high. The fraction of public schools is 0.34. Observe some significant differences between Bogotá and the aggregate data: Mainly, mean test scores are higher, average school size is bigger and the proportion of public schools is also bigger.

Table 1. Descriptive Statistics

	Mean	Stand. Deviation
Mean Score	266,86	28,58
Mean Parental Schooling	10,05	2,81
Percentage of Parents with Professional Ocupations	0,25	
Teacher's Education	15,37	1,37
Teacher-Pupil Ratio	0,06	0,02
Percentage of Schools with Infirmary	0,34	
Percentage of Schools with Computer Facilities	0,84	
Size of Graduating Class	73,56	55,86
Number of Students in School	674,68	485,21
Percentage of Public Schools	0,34	

b. Estimates of School Efficiency

Table 2 presents basic information on the distribution of efficiency scores for the three models under analysis. Three facts are immediately clear from the table. First, efficiency differences across schools are considerable: they exceed 50 percent in the polar cases. Second, average inefficiency appears to be greater than 20 percent but smaller than 30 percent. And third, the fraction of efficient schools never exceeds six percent. As expected, the variation of efficiency scores is smaller under the assumption of VRS. In addition, average and minimum efficiency are larger under in VRS than in CRS.

Table 2. Average Efficiency and Descriptive Statistics

	Model 1		Model 2		Model 3	
	CRS	VRS	CRS	VRS	CRS	VRS
Mean	75,3%	78,7%	71,4%	75,3%	75,2%	77,8%
Minimium	53,5%	55,7%	46,5%	53,1%	51,8%	55,9%
Percentage Share of Efficient Schools	2.83%	5.66%	1.56%	3.11%	3.39%	5.94%

Using different combinations of inputs and outputs can alter the rankings of individual schools. We study the change in the rankings by looking at the Spearman rank correlation coefficient between the three models described earlier. Table 3 presents the main results. Regardless of whether CRS or VRS is assumed, no big differences are apparent. The largest difference occurs between models 1 and 3, where the correlation coefficients are below 0.8.[18]

Table 3. Spearman Correlation Coefficients between Models

	Model 1	Model 2
Model 2	0.81 (CRS)	
	0.83 (VRS)	
Model 3	0.77(CRS)	0.85 (CRS)
	0.79 (VRS)	0.89 (VRS)

For policy purposes, it is important to understand how efficiency is related to variables amenable to policy changes. As a basic rule in our analysis, factors that can be easily influenced by the school are included in the DEA models, whereas factors beyond the scope of decision making power of schools are used to explain the differences in efficiency. The latter factors include average socioeconomic characteristics of the schools and whether or not the school is public. Indeed, one of the main goals of this exercise is to gauge the differences between private and public schools in terms of efficiency.

As efficiency scores are bounded between the [0, 1] interval, and there always one or more observations at upper limit, we use a Tobit model to study the determinants of efficiency. The main results are presented in Table 4. Two results are worthy of mention. First, mean parental schooling is systematically related to school efficiency: each year of parental schooling diminishes inefficiency by approximately one percentage point. And second, relative efficiency of public schools depends on the model used. In the cases that are significant, the inefficiency of public schools is small. In the rest, there are not relative efficiency differences between public and private schools, confirming the findings at the national level.
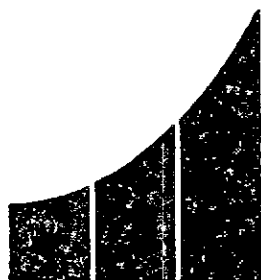
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[18] These models differ in the way they treat the total number of students: model 1 treats it as an input whereas model 3 does it as an output.

Table 4. Determinants of efficiency (Tobit models)

	Dependent variable: efficiency score (CRS)					
Variable	Model 1		Model 2		Model 3	
Percentage of Male Students	0,023 (1.62)	0,036 (2.76)**	0,007 (-0.50)	0,014 (-0.97)	0,019 (-1.21)	0,028 (-1.83)
Percentage of Parents with Professional Occupations	-0,014 (0.54)	-0,071 (2.51)*	-0,009 (0.32)	-0,035 (1.12)	-0,035 (1.20)	-0,056 (1.70)
Mean Parental Schooling	0,004 (1.75)	0,010 (3.85)**	0,008 (3.13)**	0,010 (3.69)**	0,006 (2.10)*	0,007 (2.40)*
Public school	-0,052 (6.57)**	-0,039 (5.12)**	-0,006 (0.70)	-0,007 (0.85)	-0,007 (0.75)	-0,019 (2.11)*
Size of Graduating Class		-0,00031 (5.14)**		0.00003 (0.52)		0,00033 (4.74)**
Constant	0,722 (35.82)**	0,686 (32.57)**	0,637 (29.84)**	0,607 (25.99)**	0,700 (31.23)**	0,661 (27.18)**
Observations	706	662	706	662	706	662

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

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