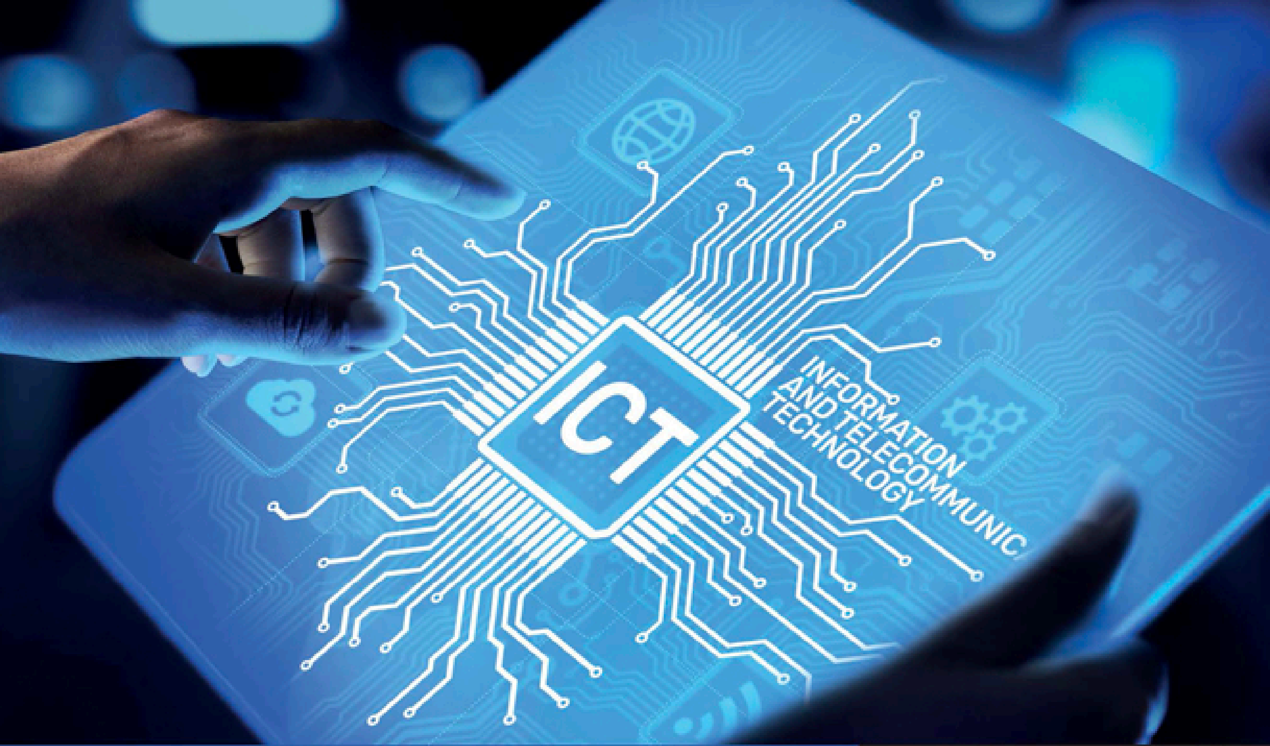

Serie *Investigación*

IMPORTANCE OF ICT IN THE TEACHING-LEARNING PROCESS:
MIDDLE AND HIGHER EDUCATION STUDIES

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Serie *Investigación*

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The integration of ICT in education entails several challenges: the first, to diagnose, at a global level, how this process is being carried out in different educational fields. Likewise, another challenge is to analyze what has really been the impact that this integration has had on improving educational quality in Colombia. It is assumed that ICT applied to education generates successful paths to promote both teaching and learning. However, it is necessary to enter the fields of education to corroborate if the previous statement is valid. A third challenge would be to analyze the effect of ICT on the efficiency of educational institutions. In this sense, it is not only necessary to determine the ICT integration process, but also to determine how the same institutions assume responsibility for the digital transformation of education. Another challenge is to validate, experiences carried out using ICT to improve learning processes. Finally, another of the challenges that can be highlighted, and is the most relevant, is the need to assume an ethical stance regarding the management of ICT in education. This book covers each of the challenges with the aim of promoting the processes of innovation and digital transformation of education from a scientific, critical, and above all, ethical perspective.

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Index

Chapter 3

Evaluating the Efficiency of schools in Bogotá and Cundinamarca: a metafrontier analysis

Juan Carlos Morales Piñero[1]

Abstract

The evaluation of educational efficiency has had a long research tradition identifying determinants in academic performance. This study seeks to determine to what extent the management carried out by the schools to achieve their academic objectives is conditioned by the sector to which they belong, the socioeconomic level of their students, and the technological pieces of equipment. For this purpose, a meta-border analysis with six models is used, applying data envelopment analysis to a population made up of 1.421 schools in Bogotá and Cundinamarca for 2016. The descriptive analysis shows that students by government schools presenting the Saber 11 Test are, on average, 2,4 times reported

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by non-government schools. The results obtained for the meta-border indicate a general inefficiency level of 16,32%. Inefficiency is reduced to 14,44% when comparing the sector to which the schools belong. Finally, when the sector and the socioeconomic level to which the schools belong are considered, the inefficiency of schools is reduced to 13,24%. The schools that benefited most from this segregation were the government schools, for which it was possible to determine that up to 30% of their inefficiency is explained by the sector and the socioeconomic level to which they belong. Likewise, it was found that government schools have better computer equipment and therefore are more sensitive to this variable. This leads us to deduce that the government schools would be giving little use to this equipment.

Keywords
Efficiency, meta-border, DEA, Secondary education.

Introduction

Studies on secondary education in Colombia have focused on analyzing educational quality, as evidenced by the numerous papers that discuss aspects related to it (Barrera, Maldonado & Rodríguez, 2012; Delgado, 2014; Loaiza & Hincapié, 2016; Marín, Riquett, Cecilia, Romero & Paredes, 2017; Marly, Jiménez & Jaramillo, 2012). However, aspects such as school management and efficiency have not received the same attention from the specialized academic community. Agasisti (2017), although in a study on higher education, highlights the importance of institutions offering greater capacity for educational services with the available resources. This premise has become relevant lately because public budgets are gradually decreasing, and it has had repercussions in the education sector. In a study, Salazar (2014) has already shown that Colombia could improve secondary education results from 6 to 10% without increasing expenditures.

Internationally, educational efficiency evaluation is long-standing, and there have been a significant number of successful academic articles (Witte & López, 2017). However, the literature available in Scopus, ScienceDirect, and Scielo focusing on studies that analyze schools' efficiency in Colombia is limited to Iregui et al. (2007) and Vélez & Psacharopoulos (1987). Only the study by Iregui et al. (2007) performs an analysis of school efficiency, using a Cobb-Douglas production function. This type of stochastic methodology is not highly recommended to analyze the efficiency in the educational field because it is very restrictive in the assumptions that it establishes, as stated by Seijas (2004), thus increasing the use of non-parametric methodologies such as Data Envelope Analysis (DEA). Specifically, in the field of secondary education, the studies by Borge & Naper (2006), Chlebounová (2019), Muñoz & Queupil (2016), Podinovski, Ismail, Bouzdine & Zhang (2014) can be highlighted, all of which use the DEA methodologies to evaluate efficiency.

To what extent does the efficiency of schools depend on their management? Iregui, Melo & Ramos (2007) indicate that the variables related to the schools' infrastructure and the students' socioeconomic environment have a positive and significant impact on their academic performance. The authors also noted that the sector which the school belongs to also influences the results. In this same sense, Marly et al. (2012) conclude that only 11% of the test results' variations are due to individual factors. Equivalent findings have been corroborated in the study presented in the second chapter of this book.

With these approaches as precedents, this study tries to determine the extent to which the schools carry out to reach their proposed academic objectives determined by the sector to which it belongs, the socioeconomic status of its students, and the technological endowment. To this end, a metafrontier analysis was carried out, applying data envelopment analysis.

Methodology

The technique used for this part of the study was data envelopment analysis (DEA), a non-parametric technique based on linear programming that determines the efficiency of a group that executes similar activities using the efficiency frontier and classifying it according to its efficiency compared to another equivalent group.

This idea is based on recognizing schools as organizations that use a set of resources to obtain a series of outputs (learning outcomes) which are the product of the combination of various inputs (resources used for teaching), thus making it possible for schools to be considered as productive units (Decision Making Unit or DMU) that manage resources to obtain certain learning outcomes. Schools are conceived in this way to identify the

DMUs that produce the highest levels of outputs using the lowest levels of inputs and thus properly use data envelopment analysis.

However, this study proposes the use of DEA understood differently as it is typically employed, since, in addition to considering the existence of outputs to be maximized, it contemplates the existence of undesirable outputs to be minimized simultaneously (Chung, Färe & Grosskopf, 1997). This perspective has already been widely applied in various sectors. Such is the case of the study by Sueyoshi & Goto (2010), who used a DEA model that included the maximization of the energy generated by various plants seeking to minimize CO2 emissions. Similarly, Watanabe & Tanaka (2007) evaluated the efficiency of the Chinese industry using an output-oriented directional distance function by comparing models that included undesirable outputs with those that did not include them. A comparison between the two measures revealed that efficiency levels are biased if only desirable production is considered. Thus, they concluded that omitting unwanted production tends to overestimate efficiency levels.

When multiple inputs are used to produce multiple outputs, Shephard's distance functions (1953, 1970) provide a functional characterization of the structure of production technology and are also closely linked to technical efficiency measures, also playing an important role in the theory of duality.

It is a productive process, with a given T technology, which transforms N inputs $x \in R^N$ into M outputs and $\in R^M_+$ y $b \in R^H_+$ unwanted outputs for "*k*" DMUs. The process can be represented as follows:

$$P_x=\{(y, b)\ |x \text{ can produce } (y, b)\ \}$$

Assuming that this set of production possibilities satisfies the classic axioms (Färe, Grosskopf & Pasurka, 2007), it is possible to define a distance function for the process, capable of measuring equiproportional movements of the productive combinations of this set to reach the limit offered by T technology (Dios & Martínez, 2010). This way, the efficiency of any of the corresponding units in P_x can be measured through the following directional distance function (DDF) (Luenberger, 1992; Oh, 2010):

$$D(x, y, b) = \max(\beta \mid (y + \beta g_y, b - \beta g_b))$$

The previous DDF determines the maximum increase and reduction achievable by β in both the desirable and undesirable outputs, respectively, on the vector g=(gy, gb) which defines the desirable directions for the improvement of both types of results. In accordance with Giménez, Prieto, Prior & Tortosa (2019), this study uses the vector of M + H components g = (y, b) as suggested by Chung et al. (1997) and Oh (2010).

Population and sample

The population under study corresponds to the schools of Cundinamarca and Bogotá D.C. who have reported the participation of their students in the Saber 11 tests of 2016. The 2016 population was originally made up of 1.937 schools that met these characteristics, according to the ICFES databases, of which 11 schools that did not report information for the variables NSE (socioeconomic status), 44 schools belonging to the NSE 1 and 408 schools belonging to the NSE 4 were excluded, because the sample was biased towards the sector (government in case NSE 1 and non-government in case 4). Finally, 55 schools that did not report information for the Total enrolled variable were excluded.

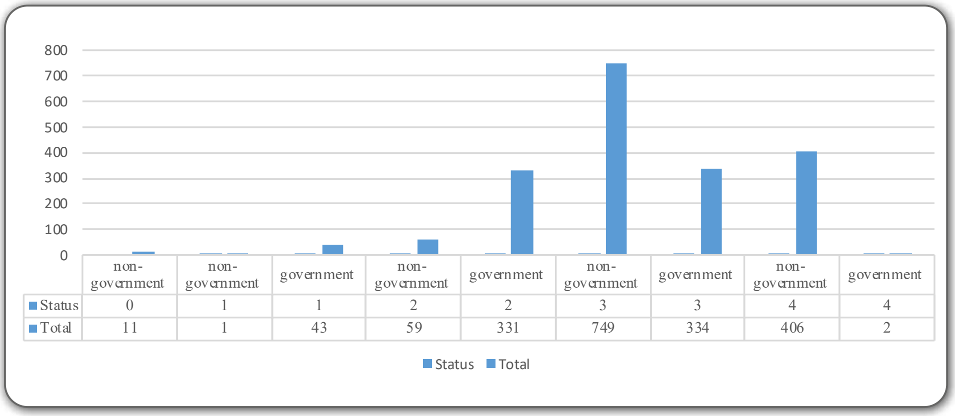

Figure 3.1. Distribution of schools by sector and NSE. The population was made up of 1.421 government and non-government schools belonging to socioeconomic status 2 and 3.

Variables

The variables used to perform the data envelope analysis are shown in table 3.1.

Table 3.1
Variables of the study

Name	Example	Description	Sources
Name of the institution	Example: INEM Francisco de Paula Santander.	Name of the headquarters where the teacher works	Ministry of Education https://sineb.mineducacion.gov.co/bcol/app
Code DANE	Example: 317380000942	DANE Code of the Institution. It was used as the unit of analysis identifier.	Ministry of Education https://sineb.mineducacion.gov.co/bcol/app
Average Pun_Global	Example: 252,37	Average calculated based on the total score obtained by those evaluated by the institution.	Data base ICFES 2016.
Attendants	Example: 87	Counting the number of students presenting the Saber 11 test in each institution.	Data base ICFES 2016.
Attendants x Average Pun_Global	Example: 2450	Variable calculated to measure the importance of the results of the Saber 11 tests according to the coverage by each institution.	Own calculation
Std. dev. Pun_Global	Example: 52,37	Standard deviation calculated based on the total score obtained by those evaluated by the institution.	Own calculation
Attendants x Std. dev. Pun_Global	Example: 1450,5	Variable calculated to measure the dispersion of the results of the Saber 11 tests according to the coverage for each institution.	Own calculation
NSE_	Example: 2 Values: 4 1 2 3 4	Variable defined by the ICFES to characterize the school based on various socioeconomic variables of its students. Level 1 presents characteristics such as the absence of a computer and internet in the homes of its students.	Data base ICFES 2016.

Name	Example	Description	Sources
Sector	Example: non-government	Nature of the educational institution, whether public (governmental) or private (non-governmental).	Data base ICFES 2016.
	Values: 2		
	non-government = 0		
	government = 1		
Total teachers	Example: 27	Number of teachers working in the institution	Data base ICFES 2016.
Total equipment	Example: 97	Indicates the installed capacity in the school's technological infrastructure: computers, tablets, laptops.	Data base ICFES 2016.
Total Enrolled	Example: 257	Number of students enrolled in the school at all levels.	Data base ICFES 2016.
Category	Example: A	It corresponds to the categorization granted by the ICFES to the school based on the performance of its students. The A + category is the best a school can achieve. N/A indicates that the school was not categorized.	Data base ICFES 2016.
	Values: 6		
	A+		
	A		
	B		
	C		
	D		
	N/A		

The following variables were defined to build the efficiency indices of the different schools (see Figure 3.2):

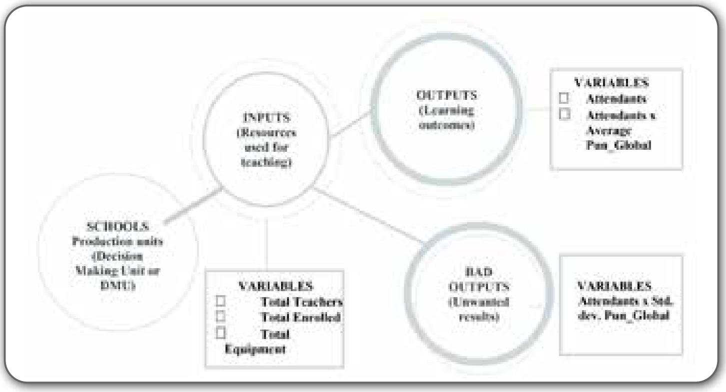

Figure 3.2. Variables of the study

Metafrontier of the study

Metafrontieranalysis is a methodology that allows comparing units that use different technologies. The traditional DEA model considers groups to be homogeneous, that is, it assumes that there are no variables present in one group of observations and not in another. However, if heterogeneous groups problems arise, methods of resolution through metafrontiers should be considered (O'Donnell, Rao & Battese, 2008).

To explain this idea in an intuitive way, suppose there is a group of DMUs for which a DEA analysis is performed assuming it is a homogeneous group. In this case, the results shown in Figure 3.3 indicate that only unit P would be efficient. If a border analysis is built by separating the analysis into two non-homogeneous groups, the *Gf* border will be obtained, where the efficient units are located. This results in two efficient units O and NO. If the K1 observation is used as an example, it could be said that the distance between Q1 and P would indicate the part of the inefficiency that would be explained by belonging to one of these groups.

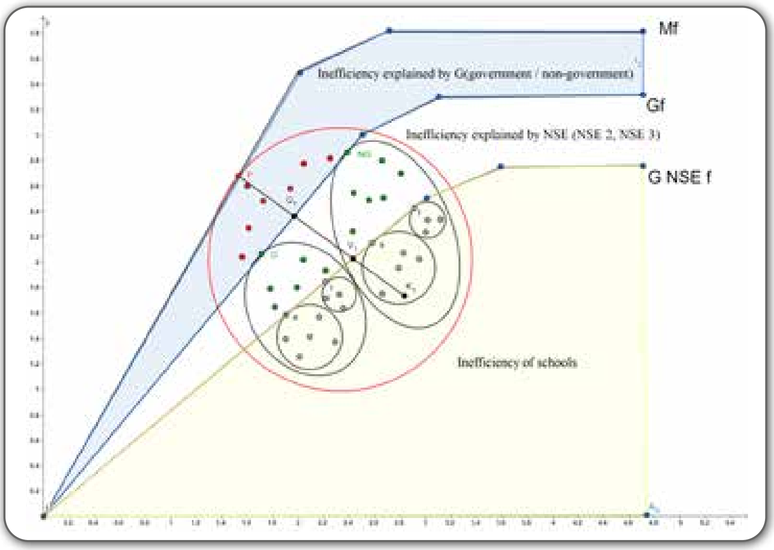

Figure 3.3. Metafrontiers by sector (G) and socioeconomic status (NSE). If a new frontier is built to highlight differences within the O and NO groups, it results in the G NSE f frontier. In this case, it turns out that the units e, r, s and t are in the efficient frontier, since the comparison was made in a more equitable way. In this case, the K1

observation could be complimented with the fact that the distance from V1 to Q1 would indicate the part of the inefficiency that would be explained by belonging to the NSE group. The rest would be the inefficiency of the K1 unit.

For this study, six models constructed as metafrontiers that allow a comparative analysis of the levels of inefficiency obtained by schools were proposed. In figure 3.4 are the models presented:

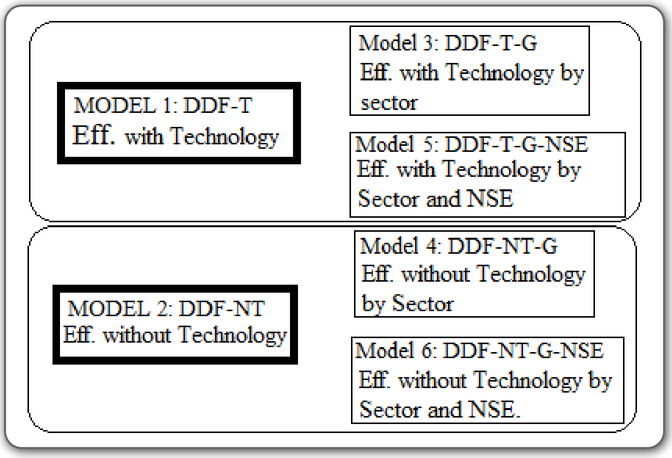

Figure 3.4. Metafrontiers defined for the study

Model 1 evaluates the level of inefficiency of schools based on the following parameters:

Output variables: Attendants and Attendants x Average Pun_Global

Unwanted output variable (bad output): Attendants x Std. dev. Pun_Global

Input variable: Total teachers; Total enrollment; and Total equipment.

Orientation: Outputs

Variable returns to scale

Model 2 evaluates the level of inefficiency of schools based on the parameters described above, assigning the value of 1 to the variable "Total equipment" for all schools. In this way, the effect of this variable in the model is eliminated without generating an imbalance that prevents the comparison of metafrontiers.

Model 3 evaluates the level of inefficiency of schools based on the parameters described for model 1, performing the calculation separately for government and non-government schools. This allows the levels of inefficiency of the schools to be calculated with the DMUs belonging to the group as a point of comparison.

Model 4 evaluates the level of inefficiency of schools based on the parameters described for model 3, performing the calculation separately for government and non-government schools. However, the variable "Total equipment" is assigned the value of 1 for all schools.

Model 5 evaluates the level of inefficiency of schools based on the parameters described for model 3, performing the calculation separately for government and non-government schools. Likewise, for each group, the calculation is made considering the Socioeconomic status reported for the school, separating the comparison for the NSE 2 and NSE 3. This allows the groups to be compared under more equitable conditions.

Finally, model 6 evaluates the level of inefficiency of the schools based on the parameters described for model 5, performing the calculation separately for government and non-government schools and considering the school's reported socioeconomic status, separating the comparison for NSE 2 and NSE 3. However, the variable "Total equipment" is assigned the value of 1 for all schools.

The R Studio software was used to calculate the DEA model.

Results

Descriptive statistics and preliminary analyzes were performed with the SPSS software. The study focused on schools from socioeconomic status 2 and 3, to not bias the study. The preliminary analysis of the information shows that non-government schools have little presence in socioeconomic status 2 (6,42%) of which 58% are not categorized. In the case of socioeconomic status 3, it is observed that the population is well distributed. It is also observed that uncategorized schools are mainly non-government schools.

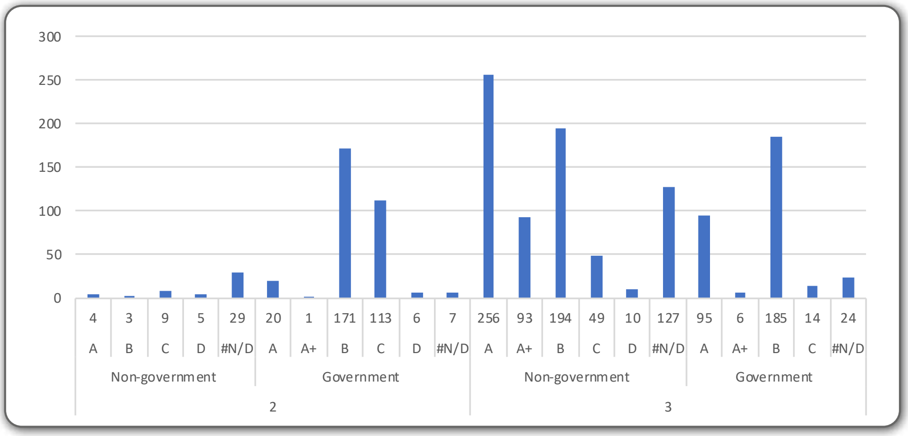

Figure 3.5. Distribution of schools according to ICFES category, sector and socioeconomic status. The number of students from government schools that present the Saber 11 Test exceeds by 2,4 times those from non-government schools (45 students per school). Likewise, it is observed that the dispersion of the data is much higher for non-government schools (46,99 students), even exceeding the average value of students per school (45 students). Looking at the results of the Saber 11 tests, they are slightly better for private (273) compared to public school (262,01). In addition, there is no significant dispersion in the results by sector.

To compare these data taking into account the impact (coverage) that these results have on the student population, the variable "Average Student of attendees x Saber 11 score" was constructed, which shows that the imbalance presented by the data by sector suggests that the comparison should be made separating the government and non-government sector.

Table 2
Descriptive statistic

VAR	Sector	Non-government	Government
01	Average Attendants	45	109,54
	Std. dev. Attendants	46,99	81,73
	Average Pun_Global	273	262,01
	Std. dev. Pun_Global	34	36,93
02	Average Attendants x Average Pun_Global	12.207	28.980,13

VAR	Sector	Non-government	Government
B1	Average Attendants x Std. dev. Pun_Global	1573	4100
I1	Average Total teachers	22,05	51,13
	Std. dev. Total Teachers	16,95	40,21
I2	Average Total Enrollment	465,78	1.228,34
	Std. dev. Total Enrolled	432,43	951,58
13	Average Total equipment	40,44	127,17
	Std. dev. Total equipment	38,79	155,60

Analyzing the inputs that the schools have to operate, it can be seen that there are no significant differences between government and non-government schools. Officials operate with a rate of 24 students per teacher and 9,67 students per computer equipment, while Non-government schools have an average of 21 students per teacher and 11 students per computer team. It is striking that the data has high dispersion, as evidenced by the values of the standard deviation.

Delving into the analysis of the results obtained by the models proposed in the metafrontiers, for model 1 the schools have a level of inefficiency of 16,32%. By removing the technological equipment from the input variables, the average level of inefficiency increases to 18,17%. However, considering that previous studies showed that the sector and the socioeconomic status were relevant variables that explain the variation in the results of the tests, differentiated models were proposed for these two variables. In this sense, models 3 (with computer equipment) and 4 (without computer equipment) show that the inefficiency of schools is reduced to 14,44% and 15,85% respectively when making the comparison by sector to which it belongs the school. Finally, models 5 and 6 evaluate the inefficiency of schools considering the sector and the socioeconomic level to which it belongs. The results indicate that when making the comparison considering these characteristics, the levels of inefficiency of the schools are reduced, even more, reaching 13,24% 8 with computer equipment and 14,72% without computer equipment. Likewise, it is observed that in all the models the inefficiency of the schools increases significantly when removing the variable that technological equipment.

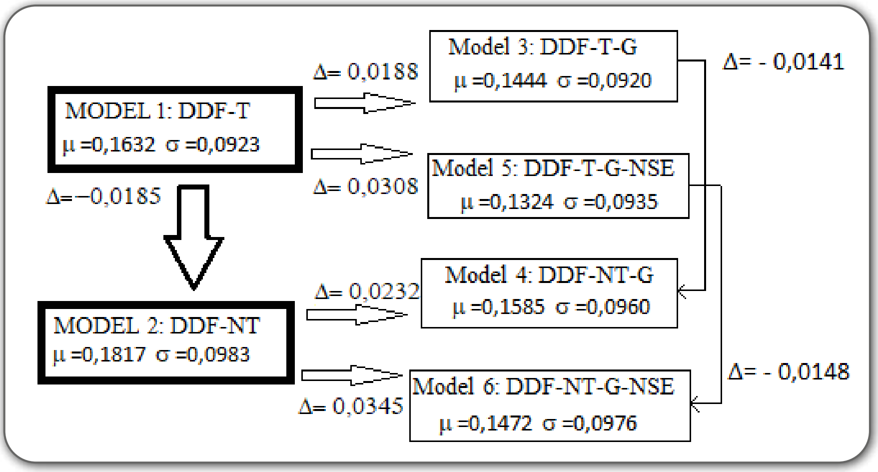

Figure 3.6. Results of the metafrontier

To analyze the results of the models in more detail, the inefficiencies of the schools were compared according to the sector which they belong to for each of the models. The results show that in all cases the schools belonging to the non-government sector obtain significantly higher levels of inefficiency than government schools. It is also observed that segregation by sector and by socioeconomic status does not significantly affect non-government schools, maintaining their levels of inefficiency in values above 17%. It is also observed that non-government schools show greater dispersion in levels of inefficiency, showing important differences between schools in the same group. Government schools show that, as their performance is evaluated considering the sector and the socioeconomic status as differentiating characteristics, their levels of inefficiency are significantly reduced, maintaining a lower dispersion in the data and a normal distribution in the data.

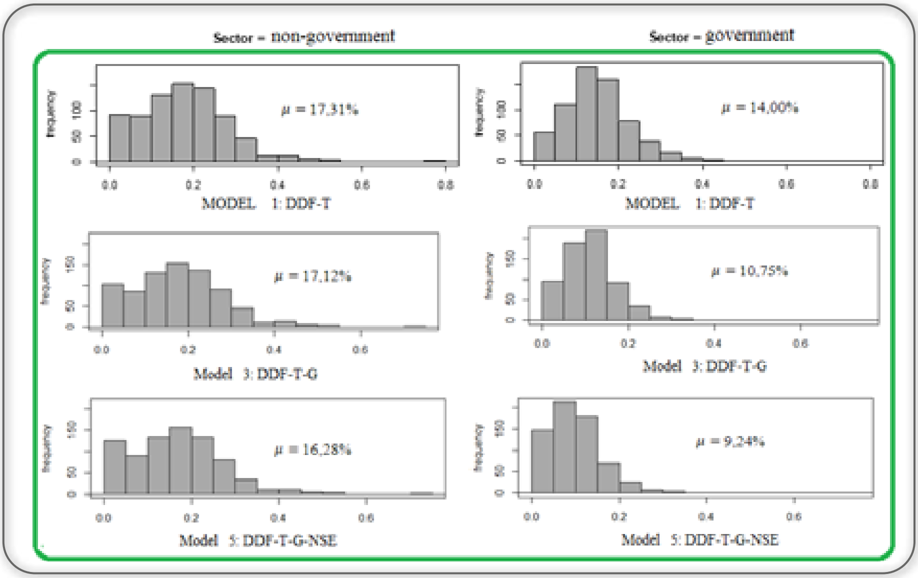

Figure 3.7. Metafrontiers by sector with technological equipment

By making the same comparison without considering the provision of computer equipment, government schools achieve a reduction of their inefficiency levels greater than 30%. In the same case, non-government schools only manage to reduce their levels of inefficiency by 8%.

These results indicate that, in the case of non-government schools, the comparison by groups segregated by sector, socioeconomic status and technological equipment only helps explain their levels of inefficiency around 8%. In the same case, government schools show that their levels of inefficiency are much lower and that these variables manage to explain their inefficiency by more than 30%, reaching values of 9,24%.

Once the evaluation of the efficiency of the schools was carried out considering differences by sector, NSE and provision of computer equipment, the correspondence of the results of the models with the categorization granted by ICFES was evaluated.

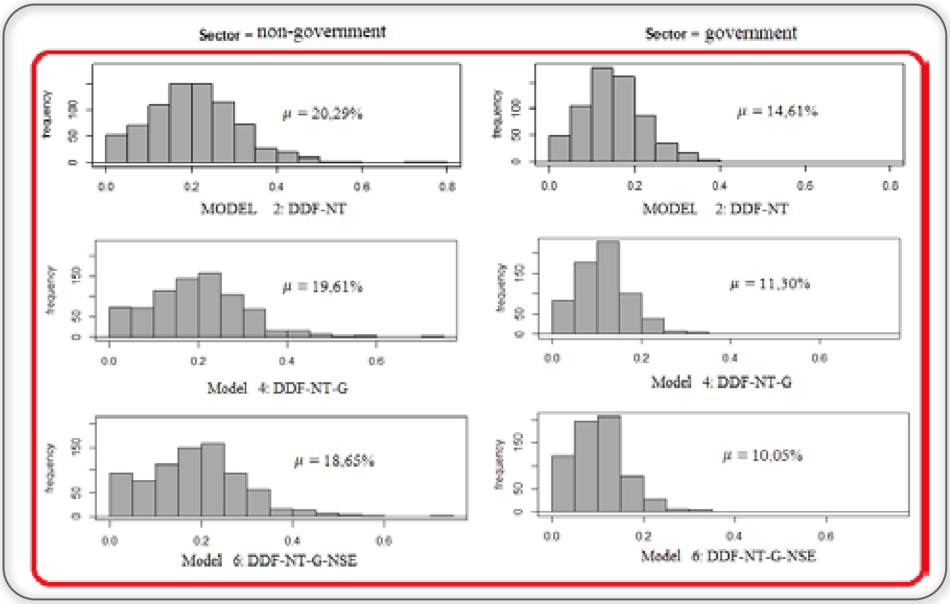

Figure 3.8. Metafrontiers by sector without computer equipment

Of the 1.421 schools analyzed, 13,2% failed to categorize for 2016, with non-government schools evidencing the highest proportion (83,42%). It can also be seen that the highest rankings are obtained by non-government schools, as they represent 93% of the schools categorized as A+ and 69,33% of the A schools. However, non-government schools also occupy the highest proportion of the lowest category (71,43%).

Focusing, then, on the schools that reach the efficient frontier in the different models, it can be observed that the results do not have a direct relationship with the categories established by the ICFES. Cases that attract the most attention are those of schools categorized as A+, since of the 100 schools that obtained this category, only 12 placed themselves on the efficient frontier. Another result that attracts special attention is category D schools: the 21 schools in this category are classified as inefficient in the case of the first four models, which is related to the categorization of ICFES. However, when evaluating its efficiency by segregating the comparison by sector and NSE, three schools manage to place themselves at the efficient frontier. This result indicates that these 21 DMUs have particularities that, when evaluated in context, manage to locate three schools on the efficient frontier, thus recognizing the particularity of the schools.

Table 3.3
Efficiency results by category according to each model

					Efficient schools according to the model					
	Category of the schools				DDF-T	DDF-NT	DDF-T-G	DDF-NT- G	DDF-T-G-NSE	DDF-NT-G-NSE
	N°	%	Government %	Non-government %	N°	N°	N°	N°	N°	N°
N/A	187	13,2	16,6	83,42	16	3	22	15	33	25
A+	100	7,0	7,0	93,00	9	7	11	10	12	11
A	375	26,4	30,7	69,33	8	5	11	8	19	14
B	553	38,9	64,4	35,63	11	7	18	11	30	18
C	185	13,0	68,7	31,36	8	6	11	9	14	11
D	21	1,5	28,6	71,43	0	0	0	0	3	3
Total	**1421**	**100**			**52**	**28**	**73**	**53**	**111**	**82**

Table 3.4 shows the results of one of these three D category schools classified as efficient are analyzed in more detail. This is a government school with NSE 2 that is compared with 19 schools that fit these variables and share equivalent input levels.

The second case presented to analyze refers to one of the 11 A+ schools that manages to be located on the efficient frontier in the "DDF-NT-G-NSE" model. This is a non-government school with NSE 3. Therefore, it will only be compared to schools in the same group. The following table shows the results, observing that the comparison is made for a group of 46 schools, leaving one of them as a reference point. It is observed that this school operates with 38 teachers, 977 students enrolled and has 74 computers. With these resources it is possible to obtain an average score of 305 with a standard deviation of 26, sending 88 students to take the exam.

Table 3.4
Detailed analysis of efficiency for an efficient D school

DMU		INEFFICIENCY	OTHER VARIABLES			OUTPUTS		BAD OUTPUTS	INPUTS		
	Code DANE	DDF-NT-G-NSE	Category	Average Pun_Global	Std. dev. Pun_Global	Attendants	Attendants x Average Pun_Global	Attendants x Std. dev. Pun_Global	Total teachers	Total Enrolled	Total equipment
1	325290002135	0	D	234	32	87	20350	2787	13	199	12
2	325754005595	0,008	D	243	32	61	14798	1976	10	221	56
3	311001110573	0,020	N/A	214	31	39	8337	1204	12	120	10
4	311001110271	0,021	N/A	229	33	71	16230	2373	10	210	21
5	311001105448	0,058	N/A	230	37	99	22815	3644	21	667	18
6	325183000663	0,040	D	218	33	48	10464	1587	13	140	15
7	325126048170	0,042	D	219	34	70	15311	2410	14	223	50
8	111001028207	0,056	N/A	236	32	32	7537	1032	151	2602	123
9	311001017531	0,084	N/A	233	27	14	3263	372	12	72	126
10	325754003428	0,087	N/A	245	36	46	11291	1675	23	703	26
11	311001093962	0,096	N/A	229	31	19	4350	594	9	107	16
12	325214047523	0,099	N/A	242	34	26	6280	884	16	160	19
13	311001109001	0,102	N/A	236	32	21	4965	682	10	193	27
14	311001109419	0,112	N/A	231	39	50	11540	1936	11	923	13
15	325758002922	0,114	D	233	39	46	10730	1787	10	213	33
16	325754001221	0,116	N/A	250	30	15	3752	446	12	395	24
17	311001089710	0,132	B	256	37	28	7177	1047	12	291	33
18	311001079862	0,135	B	258	33	17	4394	558	14	224	25
19	311001091595	0,151	N/A	248	42	42	10406	1761	16	212	40
20	325290002167	0,162	N/A	237	34	16	3788	545	11	74	20
21	425843000631	0,177	A	270	39	19	5126	732	12	186	25

Note: DEA model creates small comparable groups under the established parameters. On this set of data, one of them is established as a reference, which is the one that has the best combination of results and then calculates the potential levels of improvement (inefficiency) that each school can achieve with respect to the point of comparison. In this case, the school that moves farther away from the efficient border has a potential for improvement of 16,17%.

Table 3.5
Detailed analysis of efficiency for an efficient A+ school

DMU		INEFFICIENCY	OTHER VARIABLES			OUTPUTS		BAD OUTPUTS	INPUTS		
	Code DANE	DDF-NT-G-NSE	Category	Average Pun_Global	Std. dev. Pun_Global	Attendants	Attendants x Average Pun_Global	Attendants x Std. dev. Pun_Global	Total teachers	Total Enrolled	Total equipment
1	311001003971	0	A+	305	26	88	26832	2264	38	977	74
2	311001033510	0,044	A	303	29	101	30566	2925	51	1358	69
3	311001079901	0,046	B	266	32	124	32964	3930	45	1211	95
4	311001004897	0,047	A	289	32	139	40111	4488	52	2046	320
5	311102001007	0,050	A	284	31	103	29208	3160	39	942	51
6	311102000124	0,063	A	293	29	90	26370	2622	48	1015	124
7	325754003312	0,068	A	276	33	127	35094	4137	58	1506	81
8	325754004238	0,084	A	278	33	110	30634	3667	45	2021	38
9	325754003410	0,085	A	269	34	132	35509	4538	56	1886	117
10	311001078734	0,086	A	291	33	131	38155	4367	70	1392	34
11	311001026513	0,092	A+	303	33	102	30867	3370	46	1193	173
12	325290000030	0,100	A+	303	34	112	33975	3811	54	1112	215
13	311001027188	0,104	A	297	33	89	26422	2959	37	840	122
14	311102001244	0,108	A+	300	31	85	25459	2675	50	1323	71
15	311001012598	0,110	N/A	296	35	109	32236	3860	44	969	92
16	325754005471	0,111	B	271	35	118	32032	4126	60	1507	80
17	325899000443	0,112	A+	311	33	88	27385	2930	44	791	105
18	311001093130	0,118	A	295	34	110	32470	3793	62	1344	139
19	311001091129	0,124	A	297	35	91	27008	3168	40	1217	115
20	311001027803	0,125	B	272	32	68	18517	2169	31	834	54
21	311001036900	0,129	B	266	37	109	28978	4077	40	1154	120
22	311001006130	0,133	A+	312	34	90	28112	3068	52	1301	105
23	311279000043	0,134	A+	327	31	60	19635	1873	35	935	57
24	311001090793	0,136	A	290	33	70	20320	2296	34	713	105
25	311001000531	0,136	A+	305	32	65	19822	2103	31	867	32
26	311001041873	0,142	A	290	40	140	40577	5564	56	1879	98
27	311001032637	0,148	B	269	37	103	27719	3807	54	1316	31
28	325260000019	0,152	B	272	35	74	20130	2591	34	1043	59
29	311001001707	0,154	A+	296	37	89	26381	3310	39	777	71
30	311001038368	0,157	B	259	36	95	24588	3436	58	1412	97
31	311001050317	0,158	A	283	37	97	27414	3617	52	1114	64
32	311001092907	0,159	A	284	39	106	30153	4082	52	1324	53
33	311102001287	0,160	B	293	39	133	39003	5170	81	2165	112

DMU		INEFFICIENCY	OTHER VARIABLES			OUTPUTS		BAD OUTPUTS	INPUTS		
	Code DANE	DDF-NT-G-NSE	Category	Average Pun_Global	Std. dev. Pun_Global	Attendants	Attendants x Average Pun_Global	Attendants x Std. dev. Pun_Global	Total teachers	Total Enrolled	Total equipment
34	311001075395	0,160	B	267	39	102	27280	3964	45	1220	63
35	325307000047	0,163	A+	306	36	80	24457	2856	45	733	59
36	311001043001	0,168	B	270	37	78	21039	2890	35	832	35
37	325754002961	0,174	B	268	37	74	19846	2748	33	1193	43
38	325754003592	0,177	B	272	36	69	18750	2475	35	948	62
39	311001006466	0,178	A	291	36	85	24728	3095	57	1251	44
40	111001000353	0,181	A	288	39	92	26541	3577	49	1047	118
41	325307000055	0,182	A	288	39	94	27040	3699	49	905	104
42	325286000149	0,190	A	283	36	67	18982	2435	36	978	45
43	311001020191	0,202	C	249	37	64	15955	2389	32	1119	60
44	311769000785	0,212	B	278	38	64	17822	2440	33	862	41
45	311001042977	0,227	B	260	39	63	16353	2486	32	594	28
46	311769004233	0,267	A	291	44	69	20096	3023	41	781	35

Note: results allow observing that these 45 schools have the potential of improving their results ranging from 4,4% to 26,7%. Likewise, it is observed that this school has comparable results with 9 A+ schools, 20 A schools, 14 B schools, 1 C school and an uncategorized school.

This leads to thinking about the need to project categorizations by segregating schools by those variables that have been decisive when explaining student performance.

Conclusions

Based on the effect of the sector and the socioeconomic status referred to in Chapter 2 of this book, the evaluation of the performance of the schools was carried out with the enveloping data analysis, separating the groups in metafrontiers according to socioeconomic status and sector. In this sense, the results allowed to verify that schools that had been placed in the lowest categories by the ICFES were classified as efficient schools. The opposite also occurred.

This difference occurs because when categorizing schools under a comparison matrix that assumes group homogeneity, which part of the expected achievement is conditioned by variables that are beyond their control and that do not make it comparable with another group is forgotten. In this regard, the comparison with the DEA through non-parametric borders poses a more equitable solution.

The schools that benefited most from this segregation were government schools. It was possible to determine that up to 30% of their inefficiency is due to the sector they belong to and to their socioeconomic status.

In this sense, this study allows to conclude that, depending on the condition of the institution which the students belong to, whether public or private, the results obtained in the Saber 11 tests will be different. Thus, a government school tends to have lower results than a private one if they are compared without considering their differences.

When evaluating the efficiency of the schools through the data envelopment analysis by segregating the analysis with and without technological equipment, it was observed that, in all cases, schools increased their inefficiency by not having this variable. Likewise, it was found that government schools are better equipped in computers and therefore are more sensitive to this variable. This corroborates the results obtained in the previous regression study and would indicate that government schools would be giving little use to this equipment.

This leads to a hypothesis for further studies regarding whether standardized tests would focus only on the domain of content, as well as regarding the need to advance in longitudinal studies that evaluate the change in time that would be obtained with an adequate integration of technology, pedagogy, and content in classrooms.

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