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Technical efficiency of rural and urban municipal public schools in the state of Ceará with an analysis of the subjects of Portuguese and Mathematics

ARTICLE

Luan Oliveira dos Santos[i]
Universidade Federal do Ceará, Fortaleza, CE, Brasil
José Newton Pires Reis[ii]
Universidade Federal do Ceará, Fortaleza, CE, Brasil
Ivan de Oliveira Holanda Filho[iii]
Universidade Federal do Ceará, Fortaleza, CE, Brasil
Marcos Paulo Mesquita da Cruz[iv]
Universidade Federal do Ceará, Fortaleza, CE, Brasil
Medna N'dami[v]
Universidade Federal do Ceará, Fortaleza, CE, Brasil

Abstract
Education is fundamental for individual and collective progress, providing opportunities for growth and social mobility, in addition to directly influencing a country's economy through investments in its citizens. The main objective of this work is to analyze the efficiency of urban and rural schools in elementary school in the state of Ceará. When analyzing the results, it is observed that few municipalities reached the maximum level of efficiency in each specified model, representing a small percentage of specific locations. A difference in efficiency was found between rural and urban areas, with the rural environment generally showing lower efficiency, however, the final years show the highest average efficiency values, both in rural and urban areas.
Keywords: Education. Efficiency. Ceará.

Eficiência técnica das escolas públicas municipais rurais e urbanas do estado do Ceará com uma análise das disciplinas de Português e Matemática

Resumo
A educação é fundamental para o progresso individual e coletivo, proporcionando oportunidades de crescimento e mobilidade social, além de influenciar diretamente a economia de um país através dos investimentos em seus cidadãos. O presente trabalho tem como objetivo principal analisar a eficiência das escolas urbanas e rurais no ensino fundamental no estado do Ceará. Ao analisar os resultados, observa-se que poucos municípios alcançaram o máximo nível de eficiência em cada modelo especificado, representando uma pequena porcentagem das localidades estudadas. Foi constatada uma diferença na eficiência entre as zonas rural e urbana, com o ambiente rural apresentando geralmente menor eficiência, contudo, os anos finais apresentam os maiores valores médios de eficiência, tanto na zona rural quanto urbana.
Palavras-chave: Educação. Eficiência. Ceará

1 Introduction

Education is crucial to society, providing opportunities for personal and collective growth. Its investments have a direct impact on citizens, who are agents of social change, influencing a nation's economic performance.

Since the 1990s, Brazil has expanded primary education in all states, nearly making it universal. There was also a significant expansion of secondary education, partly due to the attention given by the 1988 Constitution to free basic education. However, despite the increase in the population's schooling, educational inequalities persist between regions, states and urban and rural areas (Rodrigues et al., 2017).

The Constitution established that municipalities should prioritize early childhood education and primary education, while states and the Federal District should prioritize primary and secondary education. However, the lack of adequate regulation has resulted in gaps in federative cooperation, leading to historical problems such as policy discontinuity, lack of articulation between programs and insufficient resources.

In 2014, the National Education Plan (PNE) was approved in Brazil, with 10-year goals aimed at universalizing primary education for children aged 6 to 14 and ensuring that, by the end of the period, at least 95% of students complete this stage at the appropriate age. The plan aims to raise public investment in basic education to at least 7% of GDP by the fifth year and to reach 10% by the end of the 10 years.

Between 2005 and 2011, public investment per student in basic education more than doubled in real terms. Controlling the efficiency of public spending has become the responsibility of schools, the state and society. Studies by Kaveski *et al.* (2013) revealed inefficiencies in public spending between 2005 and 2011 in some Brazilian federal units in the academic performance of regular high school students in state public schools, preventing the country from reaching its full potential. Technical efficiency aims to produce with the least amount of inputs, while economic efficiency seeks to produce the same amount of product at a lower cost or obtain more production at an equivalent cost.

In Brazil, according to Schettini (2014), public spending on education is disorganized, resulting in a waste of public resources. To avoid this, it is necessary to adopt

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appropriate planning and management practices on the part of the entities responsible for education. As stated by Machado *et al.*, (2018), the main factors that influence the efficiency of education are spending in the sector, the structure of the school, the socioeconomic profile of the students, family structure and other variables.

Studying education is relevant because research such as that by Barros, Henrique and Mendonça (2002), Menezes-Filho (2001) and Soares, Fontoura and Pinheiro (2007) shows that there is a relationship between an increase in the schooling of a population and other social indicators, such as a reduction in crime, an improvement in the quality of social life, a reduction in poverty, the financial independence of women, a reduction in income inequality, an increase in productivity, among others.

The study analyzes the technical efficiency of urban and rural schools in the initial and final years of primary education in the municipalities of the state of Ceará, using Data Envelopment Analysis. Unlike most studies that focus only on urban areas, this study seeks to fill this gap by also evaluating rural areas. The state of Ceará was chosen because of its prominence on the national scene. According to Pereira et al. (2022), Ceará is one of the states that developed the most between 2005 and 2019 in terms of education, whose education policy is to allocate part of the tax collection to the municipalities according to official evaluations.

The aim of this paper is to measure the technical efficiency of urban and rural schools for the initial and final years of primary education in the municipalities of Ceará, using the Data Envelopment Analysis method with inspection of the Portuguese and Mathematics subjects, in addition to verifying whether there is a difference in efficiency between urban and rural areas.

The paper is divided into three sections in addition to the introduction. The next section explains the methodology adopted, describing the database to be applied in the proposed method. The third section presents the results and their discussion. Finally, the final considerations of the study are made.

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2 Methodology

This section describes the methodological procedures used in the study, addressing the database and the non-parametric technique used to identify the efficiency of the municipalities in the initial and final years of primary education. It also seeks to investigate possible differences in efficiency between urban and rural areas.

2.1 Database

The main sources were the Instituto Nacional de Estudos e Pesquisas Educacionais Anísio Teixeira (INEP) and the Fundo Nacional de Desenvolvimento da Educação (FNDE) through the Sistema de Informações sobre Orçamentos Públicos em Educação (SIOPE), from which the data for the linear programming model was taken.

The Prova Brasil and the Sistema Nacional de Avaliação da Educação Básica (SAEB) are large-scale diagnostic assessments developed by INEP, which is linked to the Ministry of Education (MEC) and is carried out in odd-numbered years. Its aim is to assess the quality of teaching offered by the Brazilian education system using standardised tests and socio-economic questionnaires.

Data from 184 municipalities in Ceará were used to analyse the Prova Brasil/SAEB scores in Portuguese and Mathematics in 2019. Table 1 presents a descriptive analysis of the variables used as inputs and outputs of the study.

Chart 1 - Descriptive statistics of the variables used as inputs and outputs

Inputs			
Variable	**Definition**	**Description**	**Source**
Student spending	Average investment per student	Average spending per student between 2015 and 2019.	SIOPE/FNDE
Outputs			
Variable	**Definition**	**Description**	**Source**
Score_port	Saeb Portuguese scores	Average score in Portuguese obtained by elementary school students in the initial and final years in urban and rural municipal schools.	SAEB/INEP

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Score_math	Saeb Mathmatics scores	Average math score obtained by elementary school students in the initial and final years in urban and rural municipal schools.	SAEB/INEP

Source: Authors (2020).

The data was separated into initial years (5th grade) and final years (9th grade), considering schools in urban and rural areas. The average spending per student was calculated by adding up the spending of each municipality from 2015 to 2019 and dividing by five for the initial years and by four for the final years, covering the study period of the students who took the test in 2019.

The population to be studied in this study is the 184 municipalities in the state of Ceará. The DMUs (Decision-Making Units) will be the municipalities based on the results of their elementary schools, for both rural and urban areas. After checking that some municipalities did not have all the data needed for the analysis or did not have school units in a given location, they were excluded, leaving 171 for the rural early years model, 163 for the rural late years model and all 184 municipalities for the urban early years and late years models.

2.2 Data envelopment analysis

In this study, the non-parametric DEA - BCC method was used to analyze the inputs and outputs of the process in question. The method was product-oriented, which is commonly adopted in studies on public spending, recognizing that public administration seeks to provide quality education, not just minimize costs. The DEA methodology, developed by Farrell (1957) and perfected by Charnes, Cooper and Rhodes (1978), assumes the existence of a convex production frontier and allows for the comparative evaluation of the performance of independent production units, considering various inputs (student_expenditure) and outputs (grade_portuguese; grade_mathematics), in order to measure the efficiency of each unit.

The DEA approach constructs the production frontier using linear programming methods. The term "wrapper" is used because the production frontier wraps around the set of observations. DEA linear programming uses two matrices, X and Y, with the first

representing inputs and the second representing outputs. These matrices are organized as follows:

$$[X] = \begin{bmatrix} X_{11} & \cdots & X_{1n} \\ \vdots & \ddots & \vdots \\ X_{k1} & \cdots & X_{kn} \end{bmatrix} \quad \text{and} \quad [Y] = \begin{bmatrix} Y_{11} & \cdots & Y_{1n} \\ \vdots & \ddots & \vdots \\ Y_{m1} & \cdots & Y_{mn} \end{bmatrix}$$

Efficiency analyses in economics are based on production theory and the Production Possibility Set (PPC). In primary education, city halls and education departments play a central role, as they control most of the resources. The PPC is determined by the variables of inputs and outputs used by these entities, representing all feasible combinations of inputs to generate outputs, and can be represented by:

$$T = \{(x, y) \in R_+^{n+m} | x \text{ pode produzir } y\}$$

In this set, each DMUi is faced with the following problem:

$$max_{\theta\lambda}\theta$$
$$s.a.\ Y\lambda \leq x_i$$
$$\theta y_i - Y\lambda \leq 0$$
$$e\lambda = 1$$

The vectors Y and X represent the outputs and inputs of all the DMUs, with dimensions (m x I) and (n x I), respectively. The scalar parameter θ, ranging from 1 to 0, indicates the technical efficiency of the DMUs. θ equal to 1 corresponds to maximum technical efficiency. The vector λ guides the ideal combination of inputs and outputs to achieve this efficiency. θ closer to 1 indicates greater efficiency, while values close to 0 indicate lower efficiency and greater distance from the production frontier. A θ equal to 1 indicates maximum efficiency on the production possibility frontier.

Carvalho and Sousa (2014) explain that an efficiency measure such as θ = 0.25 indicates that a DMU needs to increase its product mix by 25%, while maintaining the proportions, in order to achieve technical efficiency. Figure 1 illustrates the CCR and BCC models, where two production possibility frontiers are estimated. In the CCR, only DMU B shows

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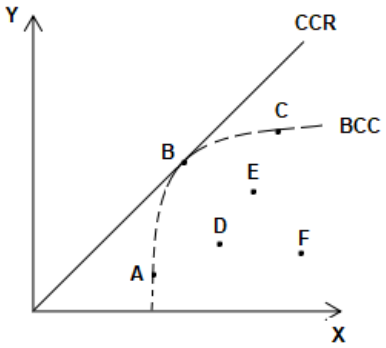
constant returns to scale and efficiency, while the other DMUs are below the frontier, showing inefficiency due to the inability to obtain constant returns to scale.

Figure 1 - DEA production frontier with constant and variable returns to scale:



Source: Prepared by the authors Araújo Júnior et al. (2016).

In the BCC model, the frontier is the dotted line. DMUs A, B and C are efficient, located on the production frontier, while DMUs D, E and F are inefficient, being below the dotted line.

The DEA CCR model can be input-oriented or output-oriented. When it is input-oriented, i.e. reducing *input* consumption while maintaining the level of *output*, the program is given by: Maximize $h_0 = \sum_{r=l}^{m} u_r y_{r0}$

Subject to:

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

$$\sum_{r=l}^{m} u_i y_{rj} \leq \sum_{i=l}^{n} v_i x_{ij}$$

$$u_r \, , v_i \geq 0$$

When *output-oriented*, i.e. increasing production given input levels, it works as follows: Minimize $h_k = \sum_{r=l}^{n} v_r x_{ik}$

Subject to:

$$\sum_{r=l}^{m} u_i y_{rk} = 1$$

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$$\sum_{r=l}^{m} u_r y_{rj} \leq \sum_{i=l}^{n} v_i x_{ij}$$

$$u_r \, , v_i \geq 0$$

The DEA BCC model can also be input-oriented or *output-oriented*. When input-oriented, it is given by: Maximize $h_0 = \sum_{r=l}^{m} u_r y_{rk} - u_k$

Subject to:

$$\sum_{r=l}^{n} v_i x_{ik}$$

$$\sum_{i=l}^{n} u_r y_{rj} - \sum_{i=l}^{n} v_i x_{ij} - u_k \leq 0$$

$$u_r \, , v_i \geq 0$$

When the DEA BCC model is *output-oriented*, the program runs as follows:

Minimize $h_k = \sum_{i=l}^{n} v_i x_{ki} + v_k$

Subject to:

$$\sum_{r=l}^{m} u_r y_{rk} = 1$$

$$\sum_{r=l}^{m} u_r y_{jr} - \sum_{i=l}^{n} v_i x_{jr} - v_k \leq 0$$

$$u_r \, , v_i \geq 0$$

For both DEA CCR and DEA BCC models, y = outputs; x = inputs; u, v = weights; r = 1, ...m; i = 1, ...n; and j = l , ..., N.

According to Machado et al. (2018) the basic assumption of DEA is that a DMU(1) is capable of producing Y(1) units of output with X(1) units of inputs and if they are operating efficiently, other DMUs could also do the same. If a DMU(2) produces Y(2) units of product using a smaller quantity of X(2) units of inputs or with the same quantity of inputs manages

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to produce a larger quantity of products than DMU(1), DMU(2) will be more efficient or DMU(1) could be considered inefficient.

The concept of efficiency used in this work is technical efficiency, which refers to the difference between the quantity actually produced with certain inputs and the quantity that could feasibly be produced with the available technology. The Production Possibility Frontier (PPF) describes what is feasible in terms of production. According to Afonso, Schuknecht and Tanzi (2006), efficiency in the production of goods is determined by the relationship between inputs and outputs, i.e. costs and benefits, and involves estimating these elements and comparing them.

3 Results and Discussion

3.1 Results of the data envelopment analysis

All the input and product variables considered in this study have low dispersion, according to the coefficients of variation shown in Table 1. It can be seen that the data is homogeneous with values of less than 12%. The municipalities of São Benedito and São Gonçalo do Amarante had, respectively, the lowest and highest spending per pupil in both the initial and final years

Table 1 - Descriptive statistics of input and output variables for municipalities in Ceará

	Variables	Average	Minimum	Maximum	Variance	Standard Deviation	Coefficient of Variation	N
				Early Years				
Rural	student_expense	5184,96	4121,34	7606,39	371042,07	609,13	11,75	
	report_grade	219,20	156,59	301,67	498,04	22,32	10,18	171
	math_grade	235,24	174,88	313,57	759,05	27,55	11,71	
Urban	student_expense	5205,48	4121,34	7606,39	384345,74	619,96	11,91	
	report_grade	221,56	174,82	291,33	377,40	19,43	8,77	184
	math_	235,60	191,37	319,48	604,88	24,59	10,44	

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	grade							
				Final Years				
Rural	student_ expense	5311,50	4152,78	7718,98	367996,17	606,63	11,42	
	port_ grade	261,52	226,06	343,14	305,26	17,47	6,68	163
	math_ grade	267,65	227,71	364,54	545,47	23,36	8,73	
Urban	student_ expense	5365,73	4152,78	7718,98	408731,90	639,32	11,91	
	report_ grade	265,58	237,38	322,34	189,44	13,76	5,18	184
	math_ grade	268,05	232,48	349,21	388,29	19,70	7,35	

Source: Prepared by the authors (2020).

For the early years, the three best municipalities in Portuguese in rural areas are Barroquinha, Quixeramobim and Martinópole; in urban areas they are Mucambo, Independência and Milhã. In math, the best in rural areas are Quixeramobim, Barroquinha and Caridade; in urban areas are Mucambo, Independência and Martinópole. For the final years, the best in Portuguese in rural areas are Pires Ferreira, Cruz and Quixeramobim; in urban areas are Pires Ferreira, Novo Oriente and Mucambo. In math, the best in rural areas are Pires Ferreira, Graça and Cruz; in urban areas are Novo Oriente, Pires Ferreira and Ararendá.

In rural areas, most municipalities had spending per pupil (59.65%), below the state average (8692.31), Portuguese assessment (58.48%) and Mathematics assessment (61.99%). In the initial years in urban areas, most municipalities also had spending per pupil (60.33%) below the total average, as well as Portuguese (57.61%) and Mathematics (60.33%) assessments below the state average. The final years in the urban area have the lowest coefficient of variation among all the estimated models, which indicates greater consistency in the Portuguese and Mathematics assessment data compared to the initial years, both in rural and urban areas.

Tables 2 and 3 show the frequencies and percentage distributions of Ceará's municipalities by efficiency class in the initial and final years, in both rural and urban areas.

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Only the initial years of rural primary education have municipalities in the efficiency class of 0.5 ≤ E < 0.6, these being Groaíras, Baixio and Aurora.

According to the Ministry of Education's "IDEB Escola" portal, in 2019 Groaíras had only two rural schools in the early years. One school did not participate in SAEB or had no enrollment at this stage, while the other obtained an IDEB of 4.1 (in 2017 it was 7.1), with lower scores in Portuguese and Mathematics. This explains its last position in the model's technical efficiency score. Data analysis reveals that the majority of rural (131 out of 171) and urban (162 out of 184) municipalities in the early years are in the technical efficiency class between 0.7 ≤ E < 1.0, as shown in Table 2.

Table 2 - Percentage distribution of municipalities by efficiency class - initial years

Early Years				
Efficiency classes	**Rural**		**Urban**	
	Frequency	**Participation (%))**	**Frequency**	**Participation (%)**
0,5 ≤ E < 0,6	3	1,75	-	-
0,6 ≤ E <0,7	33	19,30	16	8,70
0,7 ≤ E <0,8	82	47,95	107	58,15
0,8 ≤ E <0,9	34	19,88	41	22,28
0,9 ≤ E <1	15	8,77	14	7,61
E = 1	4	2,34	6	3,26

Source: Prepared by the authors (2020).

Nn the initial years model in the rural area, only 4 decision-making units (DMUs) (2.34%) achieved maximum efficiency (E = 1) and are on the production frontier: Cruz, Barroquinha, Quixeramobim and São Benedito. In the urban area, 6 DMUs (3.26%) are on the variable returns technical efficiency frontier: Martinópole, Mucambo, Pacajus, Salitre, São Benedito and Uruoca. In addition, 15 rural municipalities achieved efficiency close to the maximum (0.9 ≤ E <1), including Uruoca, Caridade, Catunda, Pacajus, Martinópole, Mucambo, Jijoca de Jericoacoara, Ararendá, Sobral, Marco, Itatira, Pires Ferreira, São João do Jaguaribe, Ipaporanga and Crato.

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In the urban early years model, 14 municipalities achieved efficiency between 0.9 ≤ E < 1. These municipalities include Jijoca de Jericoacoara, Cruz, Sobral, Independência, Marco, Milhã, Deputado Irapuan Pinheiro, Pires Ferreira, Catunda, Ararendá, Novo Oriente, Pedra Branca, Barroquinha and Frecheirinha. For the final years of urban primary education, there were no units with low efficiency.

In the rural environment, only five municipalities had efficiency between 0.6 ≤ E < 0.7: Abaiara, Miraíma, Ibicuitinga, Ererê and Moraújo. In the rural final years, four units (2.45% of all municipalities) achieved maximum efficiency: Cruz, Pacajus, Pires Ferreira and São Benedito. In the urban model, six municipalities (3.26% of the total) reached this category: Jijoca de Jericoacoara, Novo Oriente, Pacajus, Pires Ferreira, São Benedito and Sobral, as shown in Table 3.

Table 3 - Percentage distribution of municipalities by efficiency class - final years

Final Years				
Efficiency classes	**Rural**		**Urban**	
	Frequency	**Participation (%))**	**Frequency**	**Participation (%)**
0,6 ≤ E < 0,7	5	3,07	-	-
0,7 ≤ E < 0,8	74	45,40	27	14,67
0,8 ≤ E < 0,9	69	42,33	135	73,37
0,9 ≤ E < 1	11	6,75	16	8,70
E = 1	4	2,45	6	3,26

Source: Prepared by the authors (2020).

It is noteworthy that 11 rural municipalities achieved close to maximum efficiency (0.9 ≤ E <1) in the final years, with Sobral (0.996) and Uruoca (0.995) almost reaching the efficiency frontier (E = 1). Other municipalities in this class include Jijoca de Jericoacoara, Crato, Martinópole, Viçosa do Ceará, Graça, Salitre, Quixeramobim, Mucambo and Forquilha.

In the urban final years model, 16 DMUs are in the efficiency range of 0.9 ≤ E < 1, including Cruz, Mucambo, Salitre, Ararendá, Milhã, Crato, Viçosa do Ceará, Marco, Catunda, Itapajé, Russas, Horizonte, Mombaça, Itaiçaba, Quixeramobim and Groaíras.

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The technical efficiency statistics (Table 4) show that there are no major differences in average efficiency between the models. The final years show the highest average efficiency values in both urban and rural areas.

Table 4 - Descriptive statistics for technical efficiencies

Teaching Stage		Average	Minimum	Maximum	Standard Deviation	Variance	Quartile		
							1º	2º	3º
Rural	Anos Iniciais	0,767	0,558	1,000	0,091	0,008	0,704	0,742	0,822
	Anos Finais	0,813	0,687	1,000	0,069	0,005	0,766	0,806	0,856
Urban	Anos Iniciais	0,788	0,600	1,000	0,079	0,006	0,740	0,769	0,816
	Anos Finais	0,847	0,741	1,000	0,054	0,003	0,815	0,840	0,870

Source: Prepared by the authors (2020).

In rural areas, 103 municipalities (60.2% of DMUs) scored below average in the initial years, and 88 municipalities (53.9%) scored below average in the final years. The quartiles show that 25% of the least efficient rural municipalities scored 0.704 in the initial years and 0.766 in the final years.In the urban area, 109 municipalities (59.2% of DMUs) scored below average in the initial years, and 103 municipalities (55.9%) scored below average in the final years. The quartiles indicate that 25% of the urban municipalities with the lowest technical efficiency had an efficiency of 0.740 in the initial years and 0.815 in the final years.

3.2 Municipalities on the efficiency frontier

In order to deepen the results, an analysis will be made of the most efficient municipal schools, focusing on the 100 best IDEB results of 2019 in the initial and final years.

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3.2.1 Rural early years

The Ceará municipality of Cruz has 10 of the country's 100 best schools in the early years, all of which are located in rural areas, except for one. The national ranking of these schools follows the order shown in Table 5, with the first and second placed schools in 50th and 60th place respectively.

Table 5 - Best schools (EEF) in rural early years - Cruz

SCHOOL [1]	IDEB	NP Mat	NP Port	ICG	N.M	N.D	M.A.T	M.T.I
João Evangelista da Cruz	9,6	10	9,1	3	252	11	18,8	40
João Ladislau de Paulo Magalhães	9,5	10	8,9	3	253	14	17,9	40
Valdemar Paulo Ribeiro	9,3	9,8	8,8	5	68	7	11,0	0
Joaquim José Monteiro	9,2	9,7	8,7	3	160	17	14,4	39
Maria Filomena Sousa	9,0	9,1	9,0	2	92	6	18,4	0
Luis Albano da Silveira	8,8	9,1	8,5	2	82	7	12,0	0
Pedro Marques da Cunha	8,8	9,7	7,8	3	132	13	16,5	40
Dionísia Maria da Silveira	8,7	9,1	8,2	3	625	42	23,5	0
São Paulo	8,6	9,0	8,1	2	122	11	15,5	0

Source: Prepared by the authors (2020).

In Barroquinha, Ceará, two schools are among the best in the country. EEF José Augusto Ferreira took second place with an IDEB of 9.7 (previously 7.6 in 2017), achieving an average of 9.7 in the 2019 SAEB (9.9 in math and 9.5 in Portuguese) and maintaining a 100% pass rate. Despite the absence of certain structures such as a library, reading room, laboratories and sports court, the school offers a green area, internet access, broadband and computers for students (with a ratio of 78 students per computer). EEF José Machado Gouveia came 57th, with an IDEB score of 8.8 and a 100% pass rate.

In Quixeramobim, Ceará, the municipality has eight IDEB schools, including three in rural areas. EEF José Carlos da Silva is the municipality's leader and third in the state and country, with an IDEB of 9.7, excelling in math and Portuguese. With 220 enrolments

[1] NP Mat - Standardized Grade in Mathematics; NP Port - Standardized Grade in Portuguese; ICG - Management Complexity Indicator; N.M - Number of Enrolments; N. D - Number of Teachers; M.A.T - Average Number of Students per Class; M.T.I - Full-Time Enrolments.

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in 2019, including 114 full-time students, the school has 12 classes and 8 classrooms, with an average of 17.2 students per class. It has infrastructure such as a reading room, computer lab, sports court and green area, but no library or science lab. EEF Manoel Farias de Almeida is ninth in the country and second in the municipality, with an IDEB of 9.5 and excellence in mathematics. EEF Horácio Xavier do Couto, eighth in the early years in Quixeramobim, is the only rural school among those classified, with an IDEB of 8.6 and an outstanding math score (9.3). The pass rate was 100%, with more than 65% of students attending school full-time.

The municipality of São Benedito had no schools among the 100 best in the country for the early years, either in rural or urban areas.

3.2.2 Urban early years

The municipality of Martinópole has the EEF Marina Ximenes Frota, an urban school ranked 11th out of the 100 best in the country, with an IDEB of 9.4, and an outstanding standardized score for mathematics (10). Although it has a library, internet access and a sports court, it has no laboratories or computers for students to use. In Mucambo, EEF Maria Vânia Farias Linhares came in 12th place, with an IDEB of 9.4 and high scores in both Portuguese and mathematics. It has a library, patio and auditorium, but no reading room, laboratories or computers for students. In the municipality of Uruoca, despite having a rural school, it is not among the best in the country and is not on the production efficiency frontier. The other municipalities that reached the efficiency frontier did not have schools in the top 100 for the rural model.

3.2.3 Rural final years

In the municipality of Cruz, five schools were identified in the ranking of the best in Brazil (Table 6). The rankings range from 50 to 370 places, with IDEB scores between 8.3 and 7.4. The first four schools do not have a library, computer lab or science lab, but all have a reading room, internet access and broadband. The fifth school has a library.

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Table 6 - Best schools (EEF) in rural final years - Cruz

SCHOOL	Ideb	NP Mat	NP Port	ICG	N.M	N.D	M.A.T	M.T.I
João Ladislau de Paulo Magalhães	8,3	8,6	7,9	3	253	14	27,5	40
João Evangelista da Cruz	8,2	8,7	7,7	3	252	11	24,8	40
Joaquim José Monteiro	8,2	8,6	7,9	3	160	17	17,7	39
Francisco das Chagas e Silveira	7,4	7,5	7,4	2	88	6	22,0	25
Leopoldo Manoel de Medeiros	7,4	8,0	6,8	3	356	16	27,4	39

Source: Prepared by the authors (2020).

Pires Ferreira has a rural school among the 100 best in the country for the final years. EEF Antônio Silvano Balaço came third, with an IDEB of 8.5 and solid scores in math and Portuguese. The school has a library, reading room, computer lab and internet access. It has a total enrollment of 275, divided into different levels of education, with 14 classes, 6 classrooms, 22 teachers and an average number of students per class of 26.1 for the final years.

The municipalities of Pacajus and São Benedito, although they are on the frontier of production possibilities with maximum efficiency, did not have schools among the 100 best in Brazil in either rural or urban areas.

3.2.4 Urban final years

The municipality of Jijoca de Jericoacoara has four schools among the best, three of which are rural and one urban. The town of Pires Ferreira has three urban schools in the top 100 for the final years. The Francisco Ferreira Santiago, Maria Madalena Lira Passos and Alzira Maria de Araújo schools were ranked 100, 200 and 700 respectively (Table 7).

Table 7 - Best schools (EEF) urban final years - Sobral

SCHOOL	Ideb	NP Mat	NP Port	ICG	N.M	N.D	M.A.T	M.T.I	TA
Trajano de Medeiros	7,9	8,4	7,4	5	692	25	26,8	0	100
Francisco Monte	7,5	8,1	7,1	6	697	31	24,4	250	99,1
CSTI Maria de Fátima Souza Silva	7,5	7,7	7,2	1	110	8	27,5	110	100
Vicente Antenor	7,4	7,6	7,3	6	692	35	23,8	180	99,4

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CSTI Maria Dias Ibiapina	7,2	7,6	7,2	3	989	36	31,9	0	97,9
Antonio Custódio de Azevedo	7,1	7,6	6,7	6	1043	36	31,3	0	100
CSTI Mª Dorilene Arruda Aragão	7,1	7,6	6,9	2	453	20	37,8	453	97,3
Paulo Aragão	7,0	7,4	6,8	5	900	34	31,0	120	98,8
Raimundo Santana	7,0	-	-	6	410	21	24,3	0	99,0
Padre Osvaldo Chaves	7,0	8,9	7,9	5	472	18	26,8	137	97,7

Source: Prepared by the authors (2020).

The city of Novo Oriente has two urban schools among the best in the country for the final years. The Dr. Antônio Eufrasino Neto and Dr. José Maria Fernandes Leitão schools ranked 180 and 690, with good IDEB results and standardized scores in Portuguese and mathematics. Both schools have a library, computer lab, internet access and a covered patio, but no science lab, reading room or green area. The municipality of Sobral has ten schools among the best for the final years. Most schools have a reading room and internet access.

4 Final considerations

The aim of this research was to identify which municipalities are more efficient for the initial and final years of primary education and how different this technical efficiency is for rural and urban areas. The product-oriented data envelopment analysis (DEA) method was used for four models: rural early years, urban early years, rural final years and urban final years.

The most efficient municipalities were found in the initial and final years of primary education, both in rural and urban areas, and few municipalities reached the maximum level of efficiency in each model analyzed, representing a small percentage of the municipalities studied. There was a difference in efficiency between rural and urban areas, with the rural environment generally showing lower efficiency.

In the lower efficiency classes, few rural municipalities fell into these categories, while no urban municipalities fell into these specific classes. Although many rural schools

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are among the best in Brazil, the rural environment of Ceará's municipalities is in the lower efficiency brackets than the urban environment.

In short, the main suggestions and contributions for future research on this subject is to consider schools as a unit of analysis, allowing for a more precise ranking of school efficiency. Other variables, such as the Permanent System for the Evaluation of Basic Education in Ceará (SPAECE), could be included to assess students' competences and skills in Portuguese and mathematics in the initial and final years of primary and secondary education in Ceará.

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[i]**Luan Oliveira dos Santos,** ORCID: https://orcid.org/0000-0002-9827-6536
Universidade Federal do Ceará
Mestre em Economia Rural (PPGER/UFC).
Contribuição de autoria: escrita textual e metodológica.
Lattes: http://lattes.cnpq.br/0548948641438811.
E-mail: lods.luan@alu.ufc.br

[ii]**José Newton Pires Reis,** ORCID: https://orcid.org/0000-0002-7274-5189
Universidade Federal do Ceará
Professor do Departamento de Economia Agrícola e do Programa de Pós-Graduação em Economia Rural da Universidade Federal do Ceará (UFC) e doutor em Economia Agrária pela Universidade de São Paulo (USP).
Contribuição de autoria: orientação e revisão do texto final.
Lattes: http://lattes.cnpq.br/6728625638297991.
E-mail:newton@ufc.br

[iii]**Ivan de Oliveira Holanda Filho,** ORCID: https://orcid.org/0000-0002-6368-9971
Universidade Federal do Ceará
Mestrando em Economia Rural (PPGER/UFC), Pós-Graduação em Ensino de Matemática (UNIATENEU) e Licenciado em Matemática (UECE).
Contribuição de autoria: análise, discussão, correção e revisão do texto.
Lattes: http://lattes.cnpq.br/7309114743769869
E-mail: ivanfilho@ymail.com

[iv]**Marcos Paulo Mesquita da Cruz,** ORCID: https://orcid.org/0000-0001-7390-6602
Universidade Federal do Ceará
Doutorando e Mestre em Economia Rural (PPGER/UFC), Bacharel em Ciências Contábeis (UECE) e em Engenharia Metalúrgica (UFC).
Contribuição de autoria: análise, discussão, correção e revisão do texto.
Lattes: http://lattes.cnpq.br/6436408994805756
E-mail: marcos_paulo_mesquita@hotmail.com

[v]**Medna N'dami,** ORCID: https://orcid.org/0000-0002-8196-5327
Universidade Federal do Ceará
Mestrando em Economia Rural (PPGER/UFC), Graduado em engenharia agrônoma pela Universidade da Integração Internacional Lusofonia Afro-Brasileira (UNILAB).
Contribuição de autoria: análise, discussão, correção e revisão do texto.
Lattes: http://lattes.cnpq.br/4198213489532555
E-mail: mednaveira@gmail.com

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