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# EFFICIENCY AND QUALITY OF MANAGEMENT IN THE CONTEXT OF CEARÁ'S EDUCATIONAL REFORM

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## EFFICIENCY AND QUALITY OF MANAGEMENT IN THE CONTEXT OF CEARÁ'S EDUCATIONAL REFORM

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**ABSTRACT:** Education in Brazil faces challenges related to the quality and efficiency of public spending, which do not always result in improvements in learning outcomes. In this context, the state of Ceará stands out for its educational reforms, such as the redistribution of ICMS based on performance and the Literacy at the Right Age Program (PAIC), which aimed to enhance municipal education management and quality. Thus, this study evaluated the impact of these reforms on the efficiency of educational expenditures, analyzing their relationship with local public management. Data Envelopment Analysis (DEA) was used to calculate an efficiency score, and the Simar and Wilson (2007) method was applied to estimate the effect of these policies on the efficiency of municipal public spending. Finally, efficiency was related to the Municipal Management Effectiveness Index (IEGM) through multiple linear regressions. The results showed that educational reforms in Ceará had a positive impact on the efficiency of municipal spending, with municipalities that adopted better management practices demonstrating a more efficient allocation of educational resources. This reinforces the importance of municipal governance for the success of educational policies and the optimization of public spending in the sector.

**Keywords:** Educational Reforms; Educational Efficiency; DEA; Public Management.

### EFICIÊNCIA E QUALIDADE DA GESTÃO NO CONTEXTO DA REFORMA EDUCACIONAL DO CEARÁ

**RESUMO:** A educação no Brasil enfrenta desafios relacionados à qualidade e à eficiência do gasto público, que nem sempre resultam em melhorias nos resultados de aprendizagem. Nesse contexto, o estado do Ceará se destaca por suas reformas educacionais, como a redistribuição do ICMS com base no desempenho e o Programa Alfabetização na Idade Certa (PAIC), que tiveram como objetivo aprimorar a gestão e a qualidade da educação municipal. Assim, este estudo avaliou o impacto dessas reformas sobre a eficiência dos gastos educacionais, analisando sua relação com a gestão pública local. A Análise Envoltória de Dados (DEA) foi utilizada para calcular um escore de eficiência, e o método de Simar e Wilson (2007) foi aplicado para estimar o efeito dessas políticas sobre a eficiência do gasto público municipal. Por fim, a eficiência foi relacionada ao Índice de Efetividade da Gestão Municipal (IEGM)

por meio de regressões lineares múltiplas. Os resultados mostraram que as reformas educacionais no Ceará tiveram um impacto positivo na eficiência do gasto municipal, com municípios que adotaram melhores práticas de gestão apresentando uma alocação mais eficiente dos recursos educacionais. Isso reforça a importância da governança municipal para o sucesso das políticas educacionais e para a otimização do gasto público no setor.

**Palavras-chave:** Reformas Educacionais; Eficiência Educacional; DEA; Gestão Pública

## EFICIENCIA Y CALIDAD DE LA GESTIÓN EN EL CONTEXTO DE LA REFORMA EDUCATIVA DE CEARÁ

**RESUMEN:** La educación en Brasil enfrenta desafíos relacionados con la calidad y la eficiencia del gasto público, que no siempre se traducen en mejoras en los resultados de aprendizaje. En este contexto, el estado de Ceará se destaca por sus reformas educativas, como la redistribución del ICMS basada en el desempeño y el Programa Alfabetización en la Edad Adecuada (PAIC), cuyo objetivo fue mejorar la gestión y la calidad de la educación municipal. Así, este estudio evaluó el impacto de dichas reformas en la eficiencia del gasto educativo, analizando su relación con la gestión pública local. Se utilizó el Análisis Envoltante de Datos (DEA) para calcular un índice de eficiencia, y se aplicó el método de Simar y Wilson (2007) para estimar el efecto de estas políticas sobre la eficiencia del gasto público municipal. Finalmente, la eficiencia se relacionó con el Índice de Efectividad de la Gestión Municipal (IEGM) mediante regresiones lineales múltiples. Los resultados mostraron que las reformas educativas en Ceará tuvieron un impacto positivo en la eficiencia del gasto municipal, con municipios que adoptaron mejores prácticas de gestión presentando una asignación más eficiente de los recursos educativos. Esto refuerza la importancia de la gobernanza municipal para el éxito de las políticas educativas y la optimización del gasto público en el sector.

**Palabras clave:** Reformas Educativas; Eficiencia Educativa; DEA; Gestión Pública.

## 1 INTRODUCTION

Education in Brazil faces significant challenges in terms of quality and equity. Despite progress in expanding access to basic education, the country still exhibits low educational performance in international assessments. In the 2022 edition of the Programme for International Student Assessment (PISA), Brazil scored an average of 379 points in mathematics, 410 in reading, and 403 in science, ranking below the average for the Organisation for Economic Co-operation and Development (OECD) and behind Latin American countries such as Chile and Uruguay. Additionally, more than half of Brazilian students failed to reach the basic proficiency level in mathematics, reading, and science, highlighting structural difficulties in learning and teaching quality.

This unsatisfactory performance largely reflects the low efficiency of educational spending in Brazil. Although the country invests significantly in education, these resources have not consistently translated into substantial improvements in learning outcomes. According to the *Education at a Glance 2024* report, in 2021, annual public spending per student in Brazilian elementary education was only USD 3,668, far below the OECD average of USD 11,914. However, data from the Classification of Functions of Government (COFOG) 2023 indicate that in 2021 and 2022, Brazil allocated approximately 4.49% and 5.2% of its Gross Domestic Product (GDP) to education, figures comparable to those of advanced economies, which allocated 5.01% of GDP in 2021.

Over the past decades, educational reforms in Ceará have been widely studied and debated, particularly regarding financial incentive policies based on performance and technical support strategies to improve education quality. Among the main initiatives in this regard are the redistribution of the *Imposto sobre Circulação de Mercadorias e Serviços* (ICMS) based on educational indicators and the *Programa Alfabetização na Idade Certa* (PAIC). The first reform established a resource transfer model linked to municipal educational performance, while the second provided technical assistance and pedagogical support to strengthen school management and student learning (Veloso, 2024).

To improve education quality through the funds allocated to municipalities, the Government of Ceará enacted Law No. 14.023 on December 17, 2007. This legislation established criteria for distributing the ICMS revenue share, based on the Education Quality Index (IQE), the Health Quality Index (IQS), and the Environmental Quality Index (IQMA). In percentage terms, the IQE accounts for 18%, the IQS for 5%, and the IQMA for the remaining 2%.

Several studies have confirmed the positive impact of Ceará's ICMS law on municipal education (Shirasu et al., 2013; Petterini & Irffi, 2013; Brandão, 2014; Carneiro & Irffi, 2018; Silva, 2021). Marinho (2022) and Carneiro et al. (2024) analyzed the impact of the ICMS distribution law on the efficiency of educational expenditures in Ceará's municipalities, showing that the legislation provided incentives for improved educational outcomes without necessarily considering the costs required to achieve them. They highlighted that better educational results could be attributed both to financial incentives and to more efficient management. Veloso (2024) found that schools with better management practices experienced greater gains in student performance and that ICMS redistribution encouraged the allocation of resources to higher-performing schools, influencing educational equity.

In this context, a key question arises: Does the observed educational efficiency result primarily from more effective management or simply from increased funding? The central research question of this study is whether municipal administrators successfully optimized resource allocation or merely expanded investments in education without necessarily improving efficiency.

Thus, this study aims to assess the effect of Ceará's educational reforms on the efficiency of municipal educational expenditures, seeking to determine whether variations in efficiency are linked to improvements in local government management. The research was conducted in two stages: first, following Carneiro et al. (2024), the impact of the reforms on educational spending efficiency was estimated. Subsequently, the variation in efficiency was compared with a municipal management quality indicator developed by the *Tribunal de Contas dos Municípios* (Municipal Court of Accounts).

In the first stage, the study applied Data Envelopment Analysis (DEA) to calculate an efficiency score, followed by the Simar and Wilson (2007) method to estimate the effect of the law on efficiency. In the second stage, the efficiency scores of Ceará's municipalities were related to the Municipal Management Effectiveness Index (IEGM), a broad indicator of municipal management quality, using multiple linear regressions.

Overall, the results indicate that the educational reforms had a positive and statistically significant impact on the efficiency of educational expenditures in Ceará's municipalities. Furthermore, the relationship between efficiency and management quality, as measured by the IEGM, revealed that municipalities with better administrative practices allocated educational spending more efficiently. This reinforces the hypothesis that municipal governance is a key factor in the success of public policies.

This paper is structured into five sections, in addition to this introduction. Section 2 presents the Literature Review, divided into two parts: one on educational efficiency and another on educational reforms in Ceará. Section 3 describes the Methodology, detailing the estimation of efficiency scores, the impact of the legislation on educational efficiency, and the analysis of efficiency and municipal management quality. Section 4 discusses the Results, followed by Section 5, which presents the Conclusions.

## 2 LITERATURE REVIEW

### Educational Efficiency

Educational efficiency has been widely studied in the literature, particularly in the context of public management, as the resources allocated to education are often limited and subject to strict scrutiny by policymakers and society. The literature on efficiency in the education sector can be divided into two main strands: the analysis of the technical and allocative efficiency of educational institutions and the relationship between the quality of government management and educational outcomes (Johnes, 2015; Fried et al., 2008).

The technical and allocative efficiency of educational institutions is often measured by student performance on standardized assessments, considering the available educational inputs such as

funding, teacher qualifications, and school infrastructure (Cherchye et al., 2015; Cordero-Ferrera et al., 2010). Moreover, studies such as those by Portela and Thanassoulis (2001) demonstrate that efficiency methodologies like *Data Envelopment Analysis* (DEA) and *Stochastic Frontier Analysis* (SFA) enable precise evaluations of the optimal use of educational resources. Consequently, these methods have been widely used to assess the efficiency of schools and universities (Fried et al., 2008; Johnes, 2015). These approaches allow comparisons between different educational units, identifying those that operate with higher relative efficiency and providing valuable insights for evidence-based public policymaking.

Beyond quantitative methods, various studies have analyzed the factors influencing efficiency in education. Bradley et al. (2010) highlight that governance and school autonomy significantly impact the efficiency of educational systems. Similarly, research by De Witte and Kortelainen (2013) indicates that the heterogeneity of the school environment—including students' socioeconomic characteristics and the level of competition between schools—can affect educational efficiency. These findings reinforce the importance of policies that promote equity and improve learning conditions for vulnerable populations.

The relationship between the quality of government management and educational outcomes has also been extensively explored in the literature. Haelermans and De Witte (2012) argue that governance policies that enhance school autonomy and accountability have a direct impact on efficiency improvements. Additionally, Thieme et al. (2012) emphasize that decentralization of educational administration can lead to better academic results when accompanied by effective monitoring mechanisms.

Thanassoulis and Portela (2002) argue that educational policies should consider not only funding levels but also how resources are distributed and utilized. Studies such as Haelermans and De Witte (2012) demonstrate that educational efficiency can be improved through policies that encourage good management practices and greater accountability in educational institutions. The decentralization of educational management and the engagement of school communities are also identified as key determinants of efficiency in delivering educational services (Thieme et al., 2012).

Another critical factor in educational efficiency is the role of incentives in school management. The literature suggests that performance-based funding models, such as those implemented in some U.S. states, can lead to improved efficiency in public schools (Sexton et al., 2012). However, authors such as Agasisti and Johnes (2015) warn of potential adverse effects, such as the exclusion of academically struggling students to artificially boost school performance indicators. This phenomenon, known as *cream-skimming*, can undermine educational equity and exacerbate preexisting inequalities.

Comparative studies across different countries also provide valuable insights into educational efficiency. Thieme et al. (2012) conducted an efficiency analysis of educational systems in various countries, concluding that institutional factors—such as the degree of decentralization in educational management—directly impact school efficiency. Additionally, research by Aristovnik and Obadic (2014) suggests that countries with higher per capita education spending do not always achieve the best efficiency results, indicating that management quality may be a more decisive factor than the absolute volume of resources. These studies reinforce the need to combine technical efficiency with policies that ensure equity and inclusion in education access.

Literature also underscores the importance of innovation and technology in improving educational efficiency. Aristovnik (2013) finds that the adoption of educational technologies can significantly enhance the productivity of education systems, reducing costs and expanding access to quality education. Moreover, recent research suggests that *big data* and artificial intelligence can help public administrators make more informed and effective decisions regarding the allocation of educational resources (Wolszczak-Derlacz & Parteka, 2011). The use of digital platforms to monitor student performance and the personalization of learning through artificial intelligence emerge as promising strategies to maximize the efficiency of education systems.

Thus, the literature on educational efficiency highlights that, while the volume of resources is an important factor, how these resources are managed and allocated is crucial for ensuring high-quality education. Enhancing educational governance, adopting sound management practices, and using technology efficiently emerge as essential elements for optimizing education systems in various contexts. Furthermore, it is crucial for educational policies to balance efficiency and equity, ensuring that quality education is accessible to all population segments, regardless of their socioeconomic background.

## Educational Reforms in Ceará

The educational reforms implemented in the state of Ceará over the past decades have been the subject of extensive studies and debates, particularly regarding financial incentive policies based on performance and technical assistance strategies aimed at improving education quality. Two initiatives stand out in this context: the redistribution of *ICMS* (Tax on the Circulation of Goods and Services) based on educational indicators and the *Literacy at the Right Age Program (Programa Alfabetização na Idade Certa – PAIC)*. While the former represents a performance-based resource allocation model, the latter consists of a set of actions focused on technical assistance and pedagogical support for municipalities (Veloso, 2024).

Ceará's *ICMS* redistribution policy for education was a pioneer in Brazil and influenced the formulation of similar policies in other states (Shirasu, Irffi & Petterini, 2013). The legislation regulating this mechanism was initially established by *Law No. 14.023/2007* and later improved with *Law No. 15.922/2015*. This model replaced the previous resource distribution criteria, which were based on education expenditures, with a system that considers municipal educational performance. As a result, a portion of *ICMS* transfers began to be redistributed based on education quality indicators, such as results from the *Permanent System for Basic Education Assessment of Ceará (SPAECE)* and school approval rates (SEDUC, 2015). Research indicates that this policy encouraged municipalities to adopt more effective strategies for improving learning outcomes, leading to significant advancements in the state's educational indicators (Silva, 2021; Simões & Araújo, 2019).

Established in 2007, PAIC was designed as a collaborative policy between the state government and municipalities to ensure that all children were literate by the age of seven (SEDUC, 2012). The program is based on three main pillars: continuous teacher training, the provision of structured teaching materials, and intensive pedagogical monitoring (Segatto & Abrucio, 2016). At the same time, PAIC's implementation was crucial in providing technical and pedagogical support to municipal education networks, ensuring that financial incentives were accompanied by structured interventions in school management and teaching practices.

One of PAIC's distinguishing features is its emphasis on continuous assessment as a management tool. Based on SPAECE results, the Ceará government began systematically monitoring municipal progress and directing targeted interventions to those performing below expectations (SEDUC, 2016). Additionally, the program incorporated awards and symbolic incentives, such as the *Escola Nota Dez* (Top School Award), which recognizes and values schools that achieve the best literacy results (SEDUC, 2016).

Studies demonstrate that the combination of financial incentives and technical support resulted in significant improvements in education quality in Ceará. According to Costa and Carnoy (2015), the educational performance gains observed in Ceará were significantly higher than those in states that did not adopt similar policies. Likewise, Sumiya et al. (2017) highlight that PAIC's implementation had a positive impact on reducing educational inequalities within the state, particularly in historically more vulnerable municipalities.

However, despite the progress, some challenges remain. Research indicates that while *ICMS* redistribution has generated incentives to improve education quality, there is also evidence that additional funds have not always been fully invested in educational initiatives (Holanda, Barbosa & Costa, 2007). Moreover, there are indications that municipalities may be allocating more resources to schools that already perform well, potentially exacerbating intra-municipal inequalities (Irffi & Carneiro, 2018).

Other studies suggest that performance-based incentive policies can lead to distortions in municipal administrators' behavior. According to Loureiro et al. (2020), there is evidence that some municipalities focus their efforts solely on the indicators that determine *ICMS* distribution, neglecting other areas that are equally important for overall education quality. This strategic prioritization may hinder the adoption of broader and more sustainable educational policies.

Additionally, the literature highlights the need to strengthen institutional capacities in smaller municipalities, which often struggle to implement PAIC directives and efficiently utilize *ICMS* education funds (Barbosa & Holanda, 2021). Without continuous technical support and initiatives aimed at training

local administrators, the impact of these reforms may be limited in the short term, making it more difficult to establish a culture of efficient and innovative management in municipal education networks.

Another relevant aspect in evaluating these policies is their effect on educational equity. Recent studies show that although Ceará has made significant improvements in average learning indicators, regional and socioeconomic disparities in student performance persist (Lautharte et al., 2021). Municipalities with lower revenue and limited educational infrastructure tend to face greater challenges in achieving the same results as better-structured municipalities, reinforcing the need for complementary policies to reduce these inequalities.

Finally, Ceará's experience has been analyzed in the broader context of educational policies in Brazil and worldwide. Performance-based funding models combined with integrated technical assistance, as adopted in the state, have increasingly been studied as alternatives for improving public education quality in developing countries (Sumiya et al., 2017). The challenge in the coming years will be to ensure that these strategies continue to evolve and adapt to new educational demands, promoting quality education for all.

Continuing the analysis of improvements in management and educational efficiency, Marinho (2022) examined the impact of changes in the ICMS revenue-sharing rule implemented in 2007 on the managerial efficiency of public elementary schools in Ceará. Using the *Data Envelopment Analysis* (DEA) model to estimate efficiency and the *Malmquist Index* to assess educational productivity in 2007 and 2009, the results indicated a decline in total factor productivity, attributed to technological changes that reduced the efficiency frontier. The author highlights that although the ICMS revenue-sharing law provides incentives to improve educational performance, administrators tend to prioritize increasing education investments without necessarily considering the associated costs.

Similarly, Veloso (2024) investigated the role of school management quality and educational reforms in student performance in Ceará, using various econometric approaches, such as *Regression Discontinuity Design* (RDD) and *Differences-in-Differences-in-Differences* (DDD). The research assessed the impact of performance-based funding and technical assistance on learning outcomes, revealing that schools with better management showed more significant gains, particularly in the early years of elementary education. Additionally, the study analyzed how ICMS revenue redistribution influenced municipal expenditures, finding evidence that the policy did not necessarily increase education investments but encouraged resource allocation to higher-performing schools, which may have implications for educational equity.

Along these lines, Carneiro et al. (2024) investigated the effects of Ceará's ICMS revenue-sharing policy on the efficiency of educational expenditures in the state's municipalities. The study applied a combination of the *Stochastic Frontier Analysis* (SFA) for panel data and a *Differences-in-Differences* (DiD) design, comparing the results with other control groups and using the DEA method. The results indicated that the policy increased the efficiency of educational expenditures, generating an estimated aggregate savings of approximately R\$ 4.9 billion between 2008 and 2019, equivalent to 3.8% of annual education spending. The analysis also showed that improvements in efficiency were linked to better educational management at the municipal level, reinforcing the hypothesis that the policy incentivized more effective management practices.

This study contributes to the debate by deepening the understanding of the relationship between Ceará's educational reforms and the quality of municipal public management. The implemented policies, particularly PAIC and ICMS redistribution, introduced incentives to improve learning and efficiency in public spending. This study advances the discussion by examining how the effectiveness of municipal management influenced the implementation of these reforms and whether municipalities with higher administrative quality were able to maximize educational gains. Thus, this research demonstrates that the interaction between structural policies and sound management practices is essential for achieving sustained improvements in public education.

### 3 METHODS

#### Efficiency Calculation

To assess the efficiency of municipal educational expenditures, this study employed Data Envelopment Analysis (DEA), a widely used non-parametric methodology for evaluating the performance of decision-making units (DMUs) based on their input-output relationships. The DEA approach identifies the most efficient units, establishing a frontier that serves as a benchmark for comparison with other, less efficient units. Following the methodology proposed by Carneiro et al. (2024), this study applied a variable returns to scale (VRS) DEA model with an output-oriented approach, which is particularly suited for contexts where maximizing student learning outcomes is the primary objective.

Mathematically, the DEA model solves the following linear programming problem:

$$\begin{aligned} & \text{Max } \theta & [1] \\ \text{Subject to:} & \\ & \sum_{j=1}^n \lambda_j x_{ij} \leq x_{i0}, \quad i = 1, \dots, m \\ & \sum_{j=1}^n \lambda_j y_{rj} > -\theta y_{r0}, \quad r = 1, \dots, s \\ & \sum_{j=1}^n \lambda_j = 1 \\ & \lambda_j \geq 0 \quad j = 1, \dots, n \end{aligned}$$

where  $\theta$  is the efficiency,  $x_{ij}$  and  $y_{rj}$  are the inputs and outputs of the decision-making unit (DMU) under analysis, and  $\lambda_j$  are their respective weights.

Following the initial estimation of efficiency scores, the Simar and Wilson (2007) bootstrap method was applied to correct for bias and ensure the statistical robustness of the results. This procedure accounts for potential dependencies in the data and enhances the reliability of the efficiency estimates, making them suitable for subsequent regression analyses.

To evaluate the impact of the educational reforms on efficiency, this study adopted a Differences-in-Differences (DiD) approach, as outlined by Angrist and Pischke (2008). The treatment group consisted of municipalities in Ceará, while the control group comprised municipalities from the states of Paraíba, Piauí, and Rio Grande do Norte, following a methodology similar to that employed by Carneiro and Irffi (2018). The treatment period was defined as starting in 2008, coinciding with the implementation of the ICMS redistribution policy and the PAIC program.

By combining DEA with the DiD methodology, this study aims to provide a comprehensive analysis of the efficiency gains resulting from Ceará's educational reforms, offering empirical insights into the role of financial incentives and municipal governance in optimizing public education expenditures.

## Efficiency and Quality of Municipal Management

To investigate whether the efficiency gains in educational expenditures resulting from Ceará's educational reforms are linked to improvements in municipal management, this study examines the relationship between efficiency scores and indicators of public administration quality. Specifically, the Municipal Management Effectiveness Index (IEGM) and its components were used as benchmarks for assessing governance performance at the local level.

Developed by the São Paulo State Court of Accounts in 2015, the IEGM provides a comprehensive evaluation of municipal management across multiple dimensions, including education (*i-Educ*), health (*i-Saúde*), fiscal responsibility (*i-Fiscal*), and environmental governance (*i-Amb*), among others (TCE-SP, 2015). The index is calculated based on electronic questionnaires completed by municipal administrations, complemented by national datasets such as the School Census. The overall IEGM score is derived from a weighted average of its components, ensuring a multidimensional assessment of governance effectiveness (Instituto Rui Barbosa, 2024).

Given that the IEGM data for Ceará became available only in 2017, the regression analysis examining the relationship between efficiency and management quality was conducted for the years 2017 and 2019. To assess the influence of municipal management on efficiency, multiple linear regression models were estimated, incorporating IEGM scores as explanatory variables alongside control factors such as municipal socioeconomic conditions and infrastructure quality.

By integrating efficiency metrics with governance indicators, this study seeks to determine whether municipalities with stronger administrative capacity were more effective in translating financial incentives into tangible improvements in student learning. The results provide empirical insights into the role of municipal governance in enhancing the impact of performance-based funding mechanisms in public education.

Table 1 – IEGM Dimensions

Dimension	Objective	Weight in IEGM
i-Educ	The Municipal Education Index assesses municipal management in early childhood and elementary education, analyzing school evaluation, enrollment planning, education councils, and infrastructure.	20%
i-Saúde	The Municipal Health Index measures outcomes in this area, considering Primary Care, Family Health Teams, Municipal Health Councils, treatments, and vaccination programs.	20%
i-Planej	The Municipal Planning Index evaluates the consistency between planning and execution, analyzing compliance percentages, coherence between goals, and resources used.	20%
i-Fiscal	The Municipal Fiscal Management Index assesses fiscal management by considering financial and budget execution, application of earmarked resources, transparency, and compliance with the Fiscal Responsibility Law.	20%
i-Cidade	The Municipal Citizen Protection Index evaluates municipal disaster prevention planning, considering the Contingency Plan, risk identification, and Civil Defense infrastructure.	5%
i-Amb	The Municipal Environmental Management Index assesses environmental management, considering solid waste, basic sanitation, environmental education, environmental structure, and the performance of the environmental council.	10%
i-GovTI	The Municipal IT Governance Index evaluates the use of technology in public management, considering IT policies, information security, personnel training, and transparency.	5%

Source: Prepared by the author based on TCE-SE (2020) data.

## Database

To construct the efficiency scores, the study used the Basic Education Development Index (IDEB) for both early and final years of elementary education in municipal networks as the output measure. As inputs, the study considered total municipal education expenditures, provided by the National Treasury Secretariat (STN), divided by the number of enrollments in municipal schools, based on data from INEP. All monetary values were adjusted to 2019 Brazilian reais using the National Consumer Price Index (INPC). Additionally, the study included the average number of students per class and three indicators: Student Socioeconomic Level Index (INSE); School Infrastructure Quality Index (IQIE) e Teacher Qualification Quality Index (IQFD). These indices were developed by Carneiro and Irffi (2023) using data from INEP.

To analyze the determinants of inefficiency, the study considered: Age-grade distortion rate: an indicator of resource waste and discontinuity in student learning. Dropout rate: a key measure of student retention issues. Proportion of formally employed workers with higher education: a proxy for the social value attributed to education in each municipality (Carneiro et al., 2024). Table 2 presents a detailed description of the variables used as inputs, outputs and determinants of inefficiency.

Table 2 - Variables Used in the Estimation.

Classification	Variable	Description	Source
<i>Inputs</i>	Per-student expenditure	Total education expenditure / Number of enrollments	STN and Inep
	IQFD (5th grade)	Teacher Qualification Quality Index for early years of elementary education in municipal schools.	Constructed from INEP data
	IQFD (9th grade)	Teacher Qualification Quality Index for final years of elementary education in municipal schools.	Constructed from INEP data
	Students per class	Average number of students per class in municipal elementary schools.	Inep
	IQIE	School Infrastructure Quality Index for municipal schools.	Constructed from INEP data
	INSE(5th grade)	Índice do Nível Socioeconômico do aluno dos anos iniciais do Ensino Fundamental da rede municipal.	Constructed from INEP data
	INSE (9th grade)	Student Socioeconomic Level Index for final years of elementary education in municipal schools.	Constructed from INEP data
<i>Produto</i>	Ideb	IDEB score for early and final years of municipal elementary education.	Inep
<i>Determinantes da Ineficiência</i>	Age-grade distortion rate	Proportion of students with a two-year or greater gap between their age and expected grade level.	Inep
	Dropout rate	Percentage of students who abandon municipal elementary school.	Inep
	Higher Education	Proportion of formally employed workers with a completed university degree	RAIS/MTE

Source: Prepared by the authors.

Furthermore, as previously described, to examine the relationship between educational spending efficiency and management quality, the study used the IEGM and its components. Since the index was created only in 2015, and the first available data for Ceará appear in 2017, meaning after the educational reforms, the regression analysis covers only the years 2017 and 2019.

## 4 RESULTS

### Efficiency Calculation

To contextualize the analysis, Table 3 presents the descriptive statistics of the variables used for the municipalities in the sample, distinguishing between treated (Ceará) and non-treated (Paraíba, Piauí, and Rio Grande do Norte) groups before the implementation of Ceará's educational reforms in 2007. The data reveal that, in some aspects, Ceará's municipalities were better positioned than their counterparts, with higher teacher qualifications, better school infrastructure, and lower age-grade distortion and dropout rates. However, they also exhibited lower per-student expenditures, larger class sizes, and a lower socioeconomic level. These disparities highlight the importance of employing methods that control for differences among these variables.

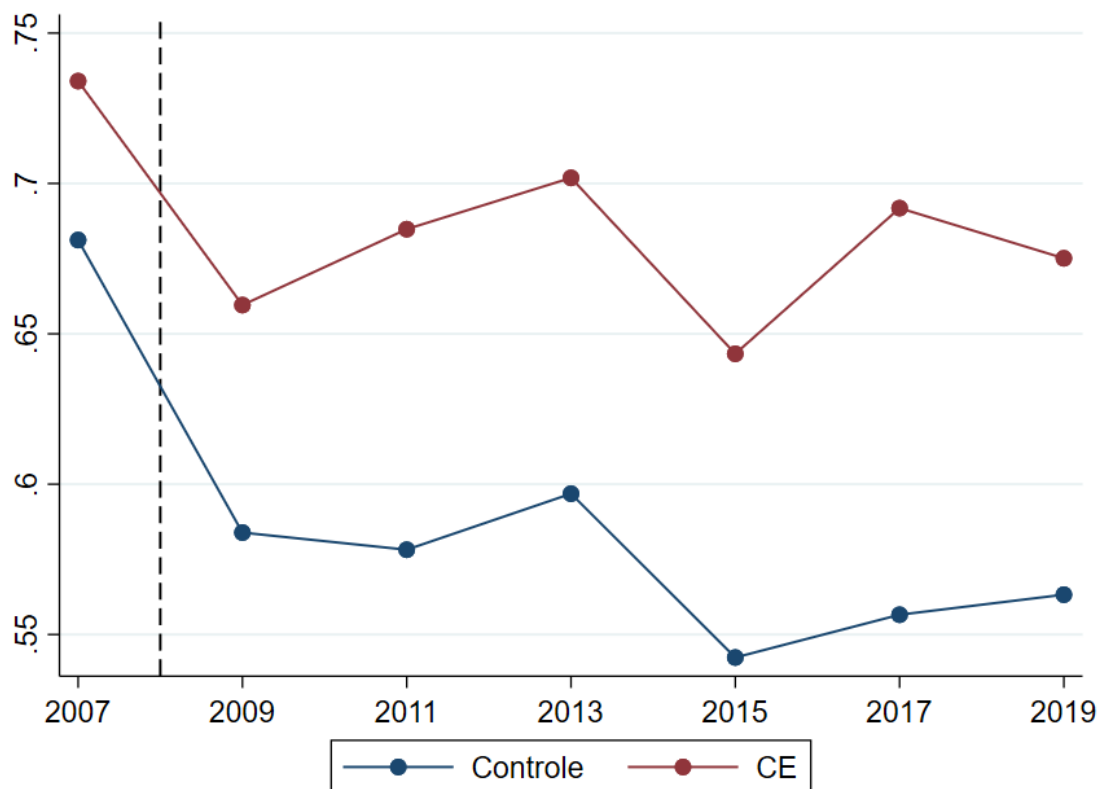
Table 3 - Descriptive Statistics of Inputs and Outputs Before Treatment.

Variables	Mean (Control Group)	Mean (Treated Group)	Difference	Standard Error	t-statistic	p-value
Per-student expenditure	3128,83	2473,72	-655,12	108,83	-6,020*	0,000
IQFD (5th grade)	0,339	0,357	0,018	0,009	2,029*	0,043
IQFD (9th grade)	0,254	0,268	0,014	0,004	3,151*	0,002
Students per class	20,665	22,531	1,866	0,312	5,989*	0,000
IQIE	0,549	0,596	0,047	0,008	5,527*	0,000
INSE(5th grade)	0,346	0,334	-0,011	0,003	-4,047*	0,000
INSE (9th grade)	0,350	0,332	-0,018	0,003	-5,504*	0,000
Age-grade distortion rate	47,562	31,849	-15,714	0,759	-20,707*	0,000
Dropout rate	8,141	4,449	-3,691	0,261	-14,157*	0,000
Higher Education	0,157	0,169	0,012	0,010	1,201	0,230

Source: Research results. \*p-value < 0.05.

Using the methodology described earlier, efficiency scores for all municipalities in the sample were estimated through Data Envelopment Analysis (DEA). Figure 1 illustrates the evolution of this indicator over time. The results show that the relative efficiency of both groups appeared to decline in the years following the reforms. However, Ceará's municipalities maintained higher average efficiency levels throughout the entire period, suggesting that the reforms may have contributed to a more effective allocation of educational resources.

Figure 1 - Temporal evolution of the average efficiency of educational spending.



Source: Research results.

Table 4 presents the estimated impact of the educational reforms on municipal efficiency levels. The findings indicate that the implementation of these policies had a positive and statistically significant effect, supporting previous studies (Carneiro et al., 2024). The estimates suggest that, on average, the reforms led to a 7-percentage-point increase in efficiency, significant at the 5% level. This result suggests that linking financial incentives to educational performance, combined with technical support for municipalities, contributed to more effective educational spending.

Additionally, among the control variables included in the analysis, dropout rates and age-grade distortion rates in elementary education exhibited statistically significant relationships with efficiency scores. Both variables were negatively correlated with efficiency, indicating that higher dropout and distortion rates are associated with resource misallocation and learning discontinuity. Conversely, the proportion of formally employed workers with higher education did not show significant effects, suggesting that this factor does not play a decisive role in variations in educational efficiency within the analyzed sample.

Table 4 – Impact of Educational Reforms on the Efficiency Educational Expenditures.

Dependent Variable: Educational Efficiency	
Time	-0,162* (0,005)
Treated (Ceará)	0,007 (0,008)
<b>Post-treatment</b>	<b>0,071*</b> (0,008)
Age-grade distortion rate	-0,001* (0,000)
Dropout rate	-0,010* (0,001)
Higher education (workers)	-0,021 (0,012)
Constant	0,795* (0,008)

Source: Research results. Note: Standard errors in parentheses. \*p-value<0.05.

The findings reinforce the hypothesis that Ceará's educational reforms positively influenced the efficiency of municipal educational expenditures. The ability of local administrators to plan, monitor, and execute public policies effectively appears to be a crucial factor in translating investments into tangible learning improvements. Municipalities with greater administrative capacity tend to utilize resources more effectively, adapting their strategies to maximize the impact of the reforms. Therefore, in the next section, we examine the extent to which municipal management quality influenced these efficiency gains, using the Municipal Management Effectiveness Index (IEGM) as a key indicator.

### Relationship Between Efficiency and the IEGM

This section examines the relationship between the efficiency of educational expenditures and the quality of municipal management, as measured by the Municipal Management Effectiveness Index (IEGM) and its components. The central hypothesis is that municipalities with more effective governance structures tend to allocate educational resources more efficiently, thus enhancing the impact of performance-based funding policies. Given that the educational database is biennial and only available up to 2019, the analysis focuses on the years 2017 and 2019.

Table 5 presents the estimated effects of municipal management quality on educational efficiency. The results indicate that higher IEGM scores are positively and significantly associated with greater efficiency, suggesting that municipalities with more structured planning and oversight mechanisms optimize their use of educational resources. Among the index's components, the *i-Educ*

dimension— which evaluates the effectiveness of local education management—had a consistently positive impact on efficiency across all models. This finding suggests that municipalities with stronger educational planning and monitoring practices are better equipped to maximize the benefits of performance-based funding mechanisms.

Additionally, the interaction between management indicators and the specific effect of Ceará provides further insights. The positive coefficient of the *i-Educ x Ceará* interaction term indicates that educational efficiency in the state was driven not only by performance-based funding but also by improvements in municipal governance. On the other hand, some components, such as *i-GovTI* (which measures IT governance), exhibited negative coefficients, indicating that weaknesses in digital infrastructure and information management may hinder the effective use of educational resources. These findings underscore the need for integrated policies that combine financial incentives with improvements in administrative capacity to maximize the impact of education funding.

Table 5 - Relationship Between Management Quality and Educational Efficiency.

Dependent Variable: Educational Efficiency					
Model	1	2	3	4	5
Ceará	0,065* (0,01)	0,043 (0,03)	0,068* (0,01)	0,012 (0,03)	0,059 (0,04)
Iegm	0,105* (0,03)	0,093* (0,03)	- -	- -	- -
Iegm x Ceará	- -	0,045 (0,07)	- -	- -	- -
i-Educ	- -	- -	0,062* (0,02)	- -	0,056* 0,02
i-Saúde	- -	- -	0,032 (0,02)	- -	0,035 0,02
i-Planej	- -	- -	-0,011 (0,02)	- -	0,013 0,02
i-Fiscal	- -	- -	0,027 (0,02)	- -	0,024 0,02
i-Cidade	- -	- -	-0,012 (0,01)	- -	-0,019 0,01
i-Amb	- -	- -	0,032* (0,01)	- -	0,03 0,02
i-GovTI	- -	- -	-0,056* (0,02)	- -	-0,068* 0,02
i-Educ x Ceará	- -	- -	- -	0,064* (0,03)	0,007 (0,04)
i-Saúde x Ceará	- -	- -	- -	-0,001 (0,04)	-0,035 (0,04)
i-Planej x Ceará	- -	- -	- -	-0,046 (0,03)	-0,058 (0,04)
i-Fiscal x Ceará	- -	- -	- -	0,031 (0,04)	0,007 (0,04)
i-Cidade x Ceará	- -	- -	- -	0,002 (0,02)	0,021 (0,02)
i-Amb x Ceará	- -	- -	- -	0,044* (0,02)	0,014 (0,03)
i-GovTI x Ceará	- -	- -	- -	-0,004 (0,04)	0,063 (0,04)
Observations	1198	1198	1198	1198	1198
Wald	1032,13	1035,55	1232,48	1087,31	1127,09
p-value	0,000	0,000	0,000	0,000	0,000

Source: Research results. Note: Standard errors in parentheses. \*p-value<0.05

The results support the conclusions of Carneiro et al. (2024) and Veloso (2024). Carneiro et al. (2024) demonstrated that the ICMS redistribution policy significantly improved the efficiency of municipal educational expenditures, suggesting that financial incentives contributed to better educational management. Veloso (2024) found that schools with stronger management practices experienced greater improvements in student performance, particularly in the early years of elementary education. These findings reinforce the argument that governance quality is a critical determinant of the success of educational policies.

Overall, the data suggest that Ceará's educational reforms not only incentivized efficiency in educational expenditures but also played a role in fostering improvements in municipal public administration. Municipalities with stronger governance structures were better able to capitalize on the incentives introduced by the reforms, enhancing the efficiency of their educational spending. Conversely, municipalities with weaker administrative capacity faced greater challenges in fully leveraging the benefits of these policies, highlighting the need for continued investment in management training and institutional development.

These findings have important implications for the broader implementation of performance-based education funding models in Brazil. The effectiveness of such policies depends not only on the financial resources allocated but also on the administrative capacity of local governments to plan and implement education strategies effectively. Future policies should consider integrating governance-strengthening initiatives alongside financial incentives to ensure sustainable improvements in educational quality and efficiency.

## 5 CONCLUSION

Education plays a fundamental role in Brazil's socioeconomic development, particularly given the persistent challenge of translating financial investments into meaningful improvements in learning outcomes. Despite the country's significant allocation of public resources to education, the results often fall short of expectations, underscoring the importance of not only increasing funding but also ensuring its effective management. In this context, Ceará has emerged as a case study of successful educational reform, implementing structural policies that link financial incentives to educational performance and encourage better management practices at the municipal level.

This study aimed to assess the impact of Ceará's educational reforms on the efficiency of municipal educational expenditures, with a particular focus on the role of public management. To achieve this objective, Data Envelopment Analysis (DEA) was used to calculate efficiency scores, while the Simar and Wilson (2007) method was applied to estimate the effect of these policies. Additionally, the study analyzed the relationship between efficiency and the Municipal Management Effectiveness Index (IEGM), providing insights into the role of governance in optimizing educational spending.

The findings indicate that Ceará's educational reforms had a positive and statistically significant impact on the efficiency of municipal expenditures, with an estimated increase in efficiency ranging between 7.7 and 8.3 percentage points. Figure 2 illustrates this trend, showing a steady improvement in the efficiency of Ceará's municipalities compared to the control group over time. These results reinforce the argument that performance-based funding mechanisms, when combined with technical and pedagogical support, can drive improvements in the allocation and use of educational resources.

Furthermore, the analysis of the relationship between efficiency and municipal management quality, as measured by the IEGM, revealed that governance plays a crucial role in enhancing the effectiveness of educational expenditures. Municipalities with more structured planning, oversight, and administrative practices demonstrated higher efficiency levels, suggesting that financial incentives alone are not sufficient to achieve sustained improvements in educational quality. The *i-Educ* component of the IEGM, which assesses education management effectiveness, was particularly relevant in explaining variations in efficiency, reinforcing the importance of structured educational planning and monitoring mechanisms.

These findings contribute to the broader debate on the role of governance in educational policy implementation. The results align with previous studies, such as those by Carneiro et al. (2024),

who demonstrated that the ICMS redistribution policy improved educational efficiency by promoting better municipal management, and Veloso (2024), who found that schools with stronger management practices achieved greater learning gains. This study expands on these analyses by demonstrating that the effectiveness of financial incentives is closely tied to the administrative capacity of local governments.

In terms of public policy, the study's conclusions are particularly relevant in light of Constitutional Amendment No. 108/2020, which mandates the implementation of the *ICMS Educacional* model across all Brazilian states. Ceará's experience suggests that while performance-based funding can be an effective tool for improving education, its success depends on complementary governance-strengthening measures. Future policies should focus not only on financial redistribution but also on providing technical assistance, capacity-building programs, and mechanisms to enhance accountability at the municipal level.

However, this study has some limitations. The IEGM data are only available for recent years, restricting the ability to conduct a long-term analysis of the relationship between management quality and educational efficiency. Additionally, the study does not directly assess how municipal administrators adapted their strategies to maximize available resources. Future research could address these gaps by incorporating more recent data, exploring alternative governance indicators, and evaluating the impact of similar policies in states that have recently adopted the *ICMS Educacional* model. This would provide a more comprehensive understanding of the replicability of Ceará's approach and its potential applicability in different regional contexts.

In conclusion, the results of this study highlight the importance of integrating financial incentives with robust governance mechanisms to ensure sustainable improvements in educational efficiency. By demonstrating that well-structured management practices amplify the benefits of performance-based funding, this research provides valuable insights for policymakers, educators, and researchers committed to enhancing the quality and equity of public education in Brazil.

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### **DECLARAÇÃO SOBRE DISPONIBILIDADE DE DADOS**

Os dados utilizados neste estudo estão disponíveis mediante solicitação aos autores.

### **CONTRIBUIÇÃO DE AUTORIA**

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### **DECLARATION OF CONFLICT OF INTEREST**

The authors declare that there is no conflict of interest related to this article.

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