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Article

Productivity analysis in resource allocation of FUNDEB in the state of Amapa between 2010 and 2019

Análise da produtividade na alocação de recursos do FUNDEB no estado do Amapá entre 2010 e 2019

Análisis de productividad en la asignación de recursos de FUNDEB en el estado de Amapa entre 2010 y 2019

Cecília Calcagno Grillo[I]

Celso Vila Nova de Souza Júnior[II]

Tito Belchior Silva Moreira[III]

César Augusto de Souza Pinto Galvão[IV]

ABSTRACT

This article analyzes the productivity in the allocation of resources from the Fund for the Maintenance and Development of Basic Education and the Valorization of Education Professionals from 2010 to 2019 with panel data, through the Malmquist Index, in the 16 municipalities of the state of Amapá, for the 5th year of elementary school. The results showed a significant inequality between the municipalities, however, even so, the Basic Education Development Index scores improved by 31.88% in the ten years analyzed. Productivity from 2010 to 2019 increased by 3.8%. The period of greatest productivity growth was between 2010 and 2011, with 17.1% growth. The period with the worst result was from 2012 to 2013, with a decline of -6.8% in total productivity.

Keywords: IDEB. Malmquist. Efficiency. Inputs. Outputs.

RESUMO

Este artigo analisa a produtividade na alocação dos recursos do Fundo de Manutenção e Desenvolvimento da Educação Básica e de Valorização dos Profissionais da Educação no período de 2010 a 2019 com dados em painel, por meio de Índice de Malmquist, nos 16 municípios do estado do Amapá, para o 5º ano do ensino fundamental. Os resultados apontaram uma expressiva

[I]Fundo Nacional de Desenvolvimento da Educação, Brasília, DF, Brazil. E-mail: cecilia.grillo@fnde.gov.br https://orcid.org/0000-0002-9393-873X

[II]Universidade de Brasília, Brasília, DF, Brazil. E-mail: celsovilanova@unb.br https://orcid.org/0000-0003-3623-9251

[III]Fundação Getúlio Vargas, Escola de Políticas Públicas e Governo, Brasília, DF, Brazil. E-mail: tito.moreira@fgv.br https://orcid.org/0000-0002-2382-1480

[IV]Escola Nacional de Administração Pública, Brasília, DF, Brazil. E-mail: cesaraugusto.galvao@gmail.com https://orcid.org/0000-0001-8522-2566

desigualdade entre os municípios, contudo, ainda assim, as notas do Índice de Desenvolvimento da Educação Básica melhoraram 31,88% nos dez anos analisados. A produtividade de 2010 a 2019 aumentou 3,8%. O período de maior crescimento da produtividade foi entre 2010 e 2011, com 17,1% de crescimento. O período que apresentou o pior resultado foi de 2012 para 2013, com declínio de -6,8% na produtividade total.

Palavras-chave: IDEB. Malmquist. Eficiência. Insumo. Produto.

RESUMEN

Este artículo analiza la productividad en la asignación de recursos del Fondo para el Mantenimiento y Desarrollo de la Educación Básica y para la Valorización de los Profesionales de la Educación de 2010 a 2019 con datos de panel, a través del Índice de Malmquist, en los 16 municipios del estado de Amapá, al 5to año de primaria. Los resultados mostraron una importante desigualdad entre los municipios, sin embargo, aun así, los puntajes del Índice de Desarrollo de la Educación Básica mejoraron en un 31,88% en los diez años analizados. La productividad de 2010 a 2019 aumentó un 3,8%. El período de mayor crecimiento de la productividad fue entre 2010 y 2011, con un crecimiento del 17,1%. El período con peor resultado fue de 2012 a 2013, con una caída de -6,8% en la productividad total.

Palabras clave: IDEB. Malmquist. Eficiencia. Insumos. Producto.

INTRODUCTION

The Federal Government plays a supplementary and complementary role in education financing policy, guaranteeing financial assistance to states, the Federal District, and municipalities (Brasil, 2009). Intending to reduce inter-regional inequality, Law No. 11.494, of June 20, 2007, in compliance with the provisions of Constitutional Amendment No. 53 of 2006, established the Fund for the Maintenance and Development of Basic Education and the Valorization of Education Professionals (*Fundo de Manutenção e Desenvolvimento da Educação Básica e de Valorização dos Profissionais da Educação*), known as Fundeb (Brasil, 2007).

Fundeb is a special fund with redistributive effects of an accounting nature. There is one fund per state and one for the Federal District, totaling twenty-seven funds formed almost entirely by resources derived from taxes and transfers from the states, the Federal District, and municipalities, linked to education by virtue of the provisions of Article 212 of the Federal Constitution. It also includes, as a supplement, a portion of federal resources, whenever, within each state, its value per student does not reach the nationally defined minimum. The program ran from 2006 to 2020 (Brasil, 2007).

The objective of educational policies is to provide quality education. To monitor and analyze the quality of education, the Basic Education Development Index (*Índice de Desenvolvimento da Educação Básica* — IDEB) was created, which is an indicator from the Ministry of Education (MEC). It is prepared by the National Institute of Educational Studies and Research (*Instituto Nacional de Estudos e Pesquisas Educacionais* — INEP) and utilizes data from the System of Basic Education Assessment (*Sistema de Avaliação da Educação Básica* — SAEB), *Prova Brasil*, in addition to school flow and dropout rates. Even though it serves as a result indicator rather than a quality indicator, improvement actions are planned based on IDEB data to enhance the quality of education (Chirinéa and Brandão, 2015).

Hence, with the aim of developing education systems, the division of responsibilities between federated entities takes place on a collaborative basis. Thus, Fundeb was created to address inter-regional inequalities, and IDEB, in turn, was created to guide actions aimed at improving the quality of education.

In 2020, with the imminent expiration of Fundeb's validity, Brazil experienced a crucial moment of transition in educational policies and the expansion of resources allocated to education through New Fundeb. Additionally, the Student Quality Cost (SQC), as provided in the recently approved Constitutional Amendment No. 108, dated August 26, 2020, which incorporated New Fundeb into the text of the Constitution, still needs to be regulated through a complementary law and will depend on studies that provide support for the decisions to be made. The studies presented here will also help to verify in the future whether SQC had the expected effects. Reflection on the efficiency in allocating Fundeb resources throughout its duration can provide an important comparative tool for the future, when New Fundeb is fully implemented. These are some of the reasons that justify carrying out this study.

Another important point for the design of this research is the need to direct efforts toward understanding education, specifically at the municipal level. This is due to the hypo-sufficiency resulting from fiscal federalism, which creates gaps in terms of service provision, financial capacity related to such provision, and dependence on the Union to achieve the desired educational results.

The state of Amapá presented one of the three worst results in Brazil in terms of social exclusion, considering the proportion of the population of young people up to 19 years of age. Furthermore, 57% of its municipalities are in the worst classification of social exclusion, according to Guerra, Pochmann, and Silva (2014), who highlight the continued low level of education, absolute poverty in large families, and income inequality in the state.

Considering this motivation, the study will encompass all 16 municipalities in the state of Amapá, based on municipal data related to the 5th year of elementary education, specifically pertaining to schools in the municipal administrative network/dependency. Panel data will be used for the time period from 2010 to 2019. Therefore, 16 municipalities will be studied over 10 years, analyzed year by year, for a total of 160 municipalities per year, which correspond to the Decision-Making Units (DMUs).

Analysis of education spending management is a fundamental necessity, given the challenges of utilizing scarce resources to enhance educational quality. This involves the dual challenge of determining the required investment amount and adopting suitable management practices to maximize the investment.

Studies on the quality of public spending and the goods and services provided by the State contribute to the development of instruments that can more accurately measure and evaluate the qualitative aspects of public spending (Almeida and Gasparini, 2011). The analysis of productivity and efficiency can result in the more efficient utilization of resources, cost reduction, improved allocation of investments, and a more precise definition of goals. In other words, it is an analysis that enhances decision-making (Piran, Lacerda and Camargo, 2018). In this sense, the present study aimed to analyze productivity in the allocation of Fundeb resources related to the 5th year of elementary education in schools in the municipal administrative network/dependency in the state of Amapá, for the period from 2010 to 2019, using panel data and the Malmquist Productivity Index.

Specific objectives include conducting a descriptive analysis of the data, identifying changes in productivity between 2010 and 2019, identifying the municipalities with the best and worst results, verifying changes in technical efficiency and technological efficiency, and estimating the trends indicated by the results found.

THEORETICAL REFERENCE

The Federative Pact established the division of responsibilities and competencies between the federated entities and, through it, charges related to the collection of taxes and provision of services were established. Fundeb was created with the aim of reducing inter-regional inequalities and thus making it possible to improve the quality of education, but this purpose depends on productivity when managing resources to be served. In this sense, the theoretical reference section is structured as follows: a brief history of the Federative Pact and education in the Federal Constitution, Fundeb, and concepts related to education productivity.

FEDERATIVE PACT AND EDUCATION IN THE CONSTITUTION

Federalism is a broad and old political-organizational concept, in which power is shared between different levels of government with overlapping responsibilities, which demands coordination of efforts (Mendes, 2004). The Federal Constitution of 1988 opted for cooperative, decentralized federalism, with education systems under the sphere of autonomy of the federative entities and a regime of reciprocal collaboration (Cury, 2008).

In a territory of enormous dimensions like Brazil, the federative pact can lead to a tendency toward fiscal imbalance due to there being a difference between revenues and expenses at different levels of government. There is greater collection capacity on the part of the national government, but the obligation to perform the service is the responsibility of the local government, therefore, the relationship causes a fiscal gap (Diniz, Lima and Martins, 2017).

Given the high demand for public goods and services, it is of utmost importance to determine the optimal level of resource transfer that ensures the efficient and equitable provision of these goods and services, as argued by Souza Júnior and Gasparini (2006) in their analysis of equity and efficiency in Brazil's 27 states within the context of fiscal federalism. The authors concluded that all Brazilian states require compensatory transfers.

BASIC EDUCATION MAINTENANCE AND DEVELOPMENT FUND

In light of the above considerations, Constitutional Amendment No. 14 created the Fund for the Maintenance and Development of Elementary Education and the Valorization of Teaching (*Fundo de Manutenção e Desenvolvimento do Ensino Fundamental e de Valorização do Magistério* – Fundef), with the goal of reducing inter-regional inequality. This fund was formulated to enhance the quality of education through increased investments in teacher appreciation. It was a special fund with redistributive effects, accounting for resources from taxes and transfers provided by states, the Federal District, and municipalities. It became effective in 1996 and lasted for ten years (Brasil, 1996).

Fundeb was created in 2007 and became effective the following year to succeed Fundef, which was set to expire in 2008. However, its policy had already become integral to public education. Similar to its predecessor, Fundeb was in effect until 2020 and consists of a portion of federal resources as a supplement whenever, within each state, the per-student value does not meet the nationally defined minimum (Brasil, 1988, 2007).

In 2020, Constitutional Amendment No. 108 was approved, establishing New Fundeb, expanding its scope permanently, and setting a minimum quality standard based on SQC (Brasil, 2020).

Supplementation of Fundeb by the Union is limited to federal units with a *per capita* value lower than the nationally defined standard. Under the previous Fundeb, 9 states received this supplement, but with the expansion through New Fundeb, a study conducted by the Budget and Financial Inspection Consultancy of the Chamber of Deputies (Haje, 2017) suggests that 24 states may now benefit from this provision.

Fundeb transfers benefit from constitutional protection, preventing discretionary interference from presidential administrations, as emphasized by Cruz (2012, 2017) in his studies on education financing. When analyzing the programs administered by the National Education Development Fund (*Fundo Nacional de Desenvolvimento da Educação* – FNDE), the author demonstrates that in 2011, municipalities were involved in managing 95.5% of the resources allocated to basic education. Of this total, the Fundeb complement constituted 48% of the resources executed by FNDE that year.

Thus, Fundeb facilitated progress in reducing interstate inequalities by expanding the range of redistributed taxes to cover all aspects of basic education. However, there remains a significant lack of equity due to resources outside the tax pool that constitutes the Fund. Despite its importance in this context, the Union's complementation still falls short of the expected supplementary function, as the investment per student remains well below international standards (Castioni, Cardoso and Capuzzo, 2020).

CONCEPTS RELATED TO PRODUCTIVITY

Sometimes the concepts of productivity and efficiency are used as synonyms; however, they present differences that will be explained below.

Productivity is the relationship between inputs, which are resources used as inputs, and outputs, which are the results (Charnes, Cooper and Rhodes, 1978), and can be represented by the ratio between inputs and outputs (Piran, Lacerda and Camargo, 2018). Technical efficiency, in turn, is the ability to employ the lowest possible level of inputs to obtain a given level of production, or the highest possible level of production with a given level of input (Rosano-Peña, 2008).

Hence, the productivity index is linked to the efficiency index. By comparing the productivity index of a particular DMU with that of the DMU showing the best performance, it forms a relationship allowing a comparison between these units, which is used to construct the efficiency index (Førsund, 2018).

Efficiency analysis requires the observation of as many factors as possible involved in the production process, so that a global analysis of production can be carried out (Skinner, 1974). Using an inadequate efficiency measure may compromise the assessment of a decision maker's performance and, as a result, wrong decisions to increase performance may be taken, such as, for example, unnecessary investment in resources that are not a priority, while critical resources remain disinvested (Piran, Lacerda and Camargo, 2018).

Farrel (1957) proposed an analysis of how companies used the inputs of their production processes to transform them into outputs. For Lapa and Neiva (1996 *apud* Belloni, 2000), productivity is a concept associated with the number of resources used for an institution to carry out its activities and the number of results achieved through these activities.

Technical efficiency, in turn, can be understood as the ability to obtain the highest possible production with a given set of inputs compared to the best-performing DMU. Scale efficiency presents an optimal operating unit that reduces efficiency as the scale of production is reduced or expanded (Piran, Lacerda and Camargo, 2018). Models that use allocative efficiency must be used when inputs and outputs are measured monetarily (Portela, 2014).

Measuring effectiveness, which is also a term often used when exploring terms such as productivity and efficiency, concerns verifying the achievement of the established goal (Minayo, 2011) regardless of the resources used (Piran, Lacerda and Camargo, 2018). Efficiency, on the other hand, has an approach that captures deeper effects than effectiveness, as it measures the qualitative and quantitative changes promoted, generally analyzed through impact studies (Minayo, 2011).

The terms presented are of fundamental importance for this study and for a clear understanding of their application in the analysis of education productivity.

EDUCATION PRODUCTIVITY

While there is extensive research on efficiency in Brazilian elementary education using Data Envelopment Analysis (DEA), studies on the evolution of productivity are less common. The majority of articles in this field tend to focus on higher education, and when it comes to basic education, a significant portion of the research comprises dissertations.

Rosano-Peña, Albuquerque, and Daher (2012) conducted a pioneering study in Brazil, evaluating the evolution of productivity and efficiency in municipal spending on elementary education in the state of Goias for the years 2005, 2007, and 2009. They utilized the Malmquist Productivity Index (MPI) in combination with DEA and the Markov Chain Technique. Their findings reinforced the idea, presented in several other studies using various methodologies, that the quality of teaching is sensitive to investments in education.

The study concluded that productivity levels increased as a result of positive changes in both productive efficiency and technology. Additionally, there was an observed trend toward reduced disparities among municipalities, with most moving toward greater efficiency. Over time, this led to a reduction in the gap between the best and the worst practices.

In a study using two-stage DEA with panel data to analyze the efficiency of Fundeb resources from 2004 to 2009 in 3,013 Brazilian municipalities, Diniz (2012) found that restrictions on Fundeb resource allocation to specific items reduced efficiency. However, the study concluded that higher Fundeb resource transfers led to increased efficiency in municipalities.

Leão (2018) analyzed technical efficiency and productivity in public elementary schools in the Federal District from 2013 to 2015 using a three-stage DEA network and MPI. The author found that efficiency tended to be higher in schools farther from the city center. However, most schools, regardless of their location, experienced a decline in overall productivity due to variations in efficiency and technological changes.

In a study by Silva (2018) analyzing efficiency and productivity indices in education and health in Brazil for the periods 2011-2013 and 2015-2017, it was found that when municipalities aimed to maximize production, their efficiency averaged 76.7%. However, an average decrease in productivity, amounting to 23.5%, was also identified. The study further observed a high spatial correlation between efficiency in health and education but found that productivity in both areas was random. Efficient municipalities influenced others in the region, but this influence did not extend to productivity in the same way.

Ferreira (2020) studied public spending on education in municipalities in Pernambuco from 2011 to 2017, evaluating the efficiency and productivity of educational expenditure using DEA and MPI. The author concluded that the municipalities in the study exhibited low efficiency with variations in productivity, which showed both increases and reductions across different phases analyzed.

Efficiency and productivity analyses are closely linked to the reality of limited resources that must be employed to attain optimal results. Hence, the fundamental principle guiding articles employing DEA and MPI for educational efficiency and productivity analysis is to utilize the minimum input necessary to achieve the highest possible level of learning and school performance (Faria, Jannuzzi and Silva, 2008; Almeida and Gasparini, 2011; Rosano-Peña, Albuquerque and Daher, 2012; Diniz, Lima and Martins, 2017; Scherer *et al*., 2019).

Analysis of quality in education should consider various factors, including educational quality, cultural and social inclusion, social inequalities, specific regional contexts and challenges, ensuring access for all, as well as social participation. These are fundamental elements for the development of genuine quality education (Carreira and Pinto, 2007).

Diniz and Corrar (2011) noted significant complexity in the vertical transfer system due to socioeconomic inequality in their study on the efficiency of Fundeb transfers. They analyzed the efficiency and the source of resources in municipal spending on elementary education using DEA and found that municipalities were more efficient when they relied more on the fund's resources. The authors highlighted the monitoring of this public policy by the federal government, together with the social control of local education councils, as fundamental factors for the efficiency of public spending. The study indicates the relevance of Fundeb to improving the conditions for providing education.

In 2007, a study by França and Gonçalves (2016) examined the relationship between Fundef, a program preceding Fundeb, and efficiency in municipal education provision in a sample of 4,438 municipalities. They discovered that participation in the fund led to the decentralization of education, resulting in an increased number of municipal schools. However, there was an inverse correlation between the volume of resources and IDEB scores. This analysis helps us understand the role of Fundef in the municipalization of education in Brazil.

Rodrigues Júnior *et al*. (2013), analyzed educational development in the Metropolitan Region of Natal, Rio Grande do Norte, using panel data from IDEB. They observed a relationship between expenses and IDEB scores. The selected model, based on econometric statistical criteria, indicated a clear relationship between the variables, demonstrating that increased investment improved the indices of the municipalities under analysis.

One of the primary purposes of funding education is to enhance the quality of basic education. A study conducted by Oliveira (2015) to analyze public financing of basic education found that this objective has been achieved. There has been a consistent improvement in student performance, fewer instances of failure and dropout, and a corresponding increase in IDEB over time.

Another study, developed by Campos and Cruz (2009), analyzed the impacts of Fundeb on the quality of basic education in the state of Rio de Janeiro and found that Fundeb did not guarantee increased funding for municipalities with more significant educational disparities, as gauged by the Human Development Index. Municipalities with fewer resources available for investment in basic education had a higher percentage of students enrolled in schools with better physical infrastructure, while municipalities with greater relative resource availability did not exhibit the same level of infrastructure quality. The authors concluded that while having an adequate availability of resources is fundamental for the provision of quality education, it alone is not sufficient to guarantee it.

According to Alves and Soares (2013), the prevailing public use of IDEB is as a unidimensional analysis factor, without considering school contexts. The study findings show that schools with students in unfavorable socioeconomic situations face greater challenges in achieving IDEB goals. Additionally, school infrastructure significantly impacts performance, particularly in the early years of elementary school.

In discussions about the term "quality," the question arises regarding the purposes of education. Is it solely about achieving good grades, or can the human values taught in schools differentiate a student's development as a citizen and professional? Another consideration is who defines what quality means. Is it the Ministry of Education's technicians, who may be removed from the classroom, or is it civil society, drawing on empirical observations? Or perhaps universities and schools themselves? There is no consensus on these matters (Carreira and Pinto, 2007).

It is essential to acknowledge that the evaluation systems developed are important, but they are clearly insufficient (Carreira and Pinto, 2007). Furthermore, the study proposed here is not exhaustive. Using IDEB as a reference for educational quality has weaknesses, as it is an index of results rather than quality. Therefore, there is a need for additional qualitative studies based on different quality criteria to ensure that the analysis of quality encompasses diverse perspectives and specificities.

METHODOLOGY

This section presents the chosen method for measuring productivity in the allocation of Fundeb resources. Initially, DEA and MPI will be introduced to provide an overview of productivity between 2010 and 2019 in the state of Amapá. Following that, the research database, along with the instruments and data collection procedures, is described.

DATA ENVELOPMENT ANALYSIS AND THE MALMQUIST PRODUCTIVITY INDEX

Inspired by the work of Farrell (1957), which initiated the discussion on the empirical measurement of productive efficiency, the DEA technique was developed by Charnes, Cooper and Rhodes (1978). They were interested in creating a method to measure the efficiency of decision-making, particularly for evaluating public policies. According to the authors, the use of the term DMUs underscores the DEA's focus on analyzing public programs, as it does not rely on market prices as a reference; instead, it works with variables that do not have a structure of relative prices (Charnes, Cooper and Rhodes, 1978).

Efficiency index can be measured using both parametric and non-parametric methods. The DEA statistical technique is non-parametric and is characterized by its ability to simultaneously use multiple inputs and outputs without imposing a specific functional form on the frontier (Almeida and Gasparini, 2011).

DEA has two commonly used models. The CCR model, named after Charnes, Cooper, and Rhodes (1978), represents the efficient frontier as a straight line due to the constant return to scale. Conversely, the BCC model, in homage to Banker, Charnes, and Cooper (1984), represents the efficient frontier as a curve because the return to scale is variable. This variation results in performance that can be either increasingly smaller or larger as input consumption increases (Ji and Lee, 2010; Wilbert and D'Abreu, 2013).

It is also worth noting that, apart from choosing the model, it is necessary to establish the analysis perspective concerning input orientation, which minimizes the number of inputs while keeping the product constant, or output orientation, which maximizes the products while keeping input quantities fixed (Kaveski, Martins and Scarpin, 2015).

According to Lapa and Neiva (1996 *apud* Belloni, 2000), productivity, in turn, is a concept associated with the quantities of resources used by an institution to carry out its activities and the quantities of results achieved through these activities.

The DEA technique, in combination with the MPI, allows for the comparison of adjacent periods using DEA analysis with the inputs and outputs of a base period. This is a significant advantage of this method because, in the case of panel data, using only DEA can compromise the analysis and results. When using all DMUs at once, the technique does not account for market dynamics, in which DMUs may be efficient in some periods and inefficient in others. Therefore, MPI is a valuable tool for measuring the changes in productivity of DMUs over time (Almeida, 2010).

The Malmquist index was introduced by Malmquist in 1953 and later applied by Caves, Christensen, and Diewert in 1982. Färe *et al*. (1994) extended the method to allow for the analysis of absolute productivity evolution (MPI) in an intertemporal model, enabling the identification of Total Factor Productivity. This total productivity can be decomposed into two parts: one reflects changes in relative technical efficiency, denoted by terms outside the brackets in Equation 1, while the other represents shifts in the frontier through changes in the technological process, illustrated by the part of the Equation 1 inside the brackets, as shown below.

$$\underbrace{m_o(y_s, x_s, y_t, x_t)}_{MPI} = \underbrace{\frac{d_0^t(y_t, x_t)}{d_0^s(y_s, x_s)}}_{EFF} \underbrace{\left[\frac{d_o^s(y_t, x_t)}{d_o^t(y_t, x_t)} \times \frac{d_o^s(y_s, x_s)}{d_o^t(y_s, x_s)}\right]^{\frac{1}{2}}}_{TECH} \quad (1)$$

The matching is represented by technical efficiency (EFF), also known as productive efficiency. It can be decomposed into pure technical efficiency (PE) and scale efficiency (SE), as demonstrated in Equation 2. The frontier shift is represented by efficiency technology (TECH). Total Productivity comprises technological efficiency and technical efficiency, as shown in Equation 3 (Rosano-Peña, Albuquerque and Daher, 2012).

$$EFF = PE \times SE \tag{2}$$

$$MPI = TECH \times EFF = TECH \times PE \times SE \tag{3}$$

This way, MPI analysis also takes into account frontier changes resulting from technological advancements. As new educational practices and laws come into effect, they contribute to this decomposition, enabling the comparison of productivity between 2010 and 2019.

The result can take one of three values: equal to 1, indicating the maintenance of the productivity factor; greater than 1, signifying growth; or less than 1, indicating a decline. Additionally, MPI analysis enables the identification of whether the increase in productivity is due to advancements in technology, improvements in total efficiency, or both (Almeida, 2010).

To facilitate understanding in a simplified manner, the analysis of MPI occurs in seven stages. First, the distance of DMU in period 0 in relation to the frontier of the same period is calculated. Then, in the same period, it is related to the frontier of period t. Subsequently, in period 0, DMU's distance in relation to the frontier of period t is determined. By using these distances, technological changes and efficiency changes are calculated, and the Malmquist index is obtained by multiplying them.

RESEARCH PARTICIPANTS, INSTRUMENTS, AND DATA COLLECT PROCEDURES

In terms of typology, this research is characterized as descriptive. The approach to the problem is predominantly quantitative. The study is operationalized through the use of secondary data, employing a documentary research procedure.

The state of Amapá presented one of the three worst results in Brazil in terms of social exclusion when considering the proportion of the population aged up to 19 years. Additionally, according to Guerra, Pochmann, and Silva (2014), 57% of its municipalities fall into the worst classification of social exclusion. They highlight the persistent low level of education, absolute poverty in large families, and income inequality in the state.

Furthermore, in the comparison of the 2019 IDEB performance among federation units, Amapá had the worst performance, tied with Pará (Brasil, 2021a). This highlights the necessity of examining the state's reality more closely to better understand the dynamics that contributed to this outcome.

For this purpose, it is relevant to focus on a specific education network. Therefore, the sample will utilize municipal data related to the 5th year of primary education, specifically from schools within the municipal administrative network/dependency. The analysis will involve panel data covering the time interval from 2010 to 2019, which means that 16 municipalities will be studied over a period of 10 years. This corresponds to a total of 160 municipalities per year, which are considered DMUs.

Faria, Jannuzzi, and Silva (2008) noted that in economically disadvantaged municipalities, the expected output tends to be lower compared to less economically disadvantaged municipalities. In this context, data related to infrastructure and capital play a crucial role in forming a more accurate assessment of the environment in which schools operate. If two municipalities have similar expenses but significantly different infrastructures, it should be taken into account that the expected output is lower in the municipality with poorer infrastructure.

The number of resources transferred and automatically spent under Fundeb was obtained by extracting data from the National Treasury Secretariat system for each municipality in the state of Amapá, corrected using the National Consumer Price Index (*Índice Nacional de Preços ao Consumidor* — IPCA). The transfers were adjusted to a value that accounts for the proportion of enrollments in the 5th year of the municipal network by each municipality, as shown below.

$$\text{Proportional Transfer from Fundeb} = \frac{\text{Total Fundeb Resources}}{\text{Total Fundeb Enrollments}} \times \text{5th} - \text{year enrollment}$$

The number of students per teacher (AP) was used for all initial years, specifically from the 1st to the 5th year. This variable provides evidence of teacher overload and/or classroom overcrowding. The number of students used for various grade levels was extracted from the Statistical Synopsis, and the data related to the Gross Domestic Product (GDP) were obtained from the Brazilian Institute of Geography and Statistics ([*Instituto Brasileiro de Geografia e Estatística* — IBGE] Brasil, 2021b) and adjusted per capita using the number of 5th-year students (Table 1).

Table 1 – Municipalities analyzed, inputs and output

Municipality	Inputs	Output
Amapá	Fundeb proportional transfer deflated. AP LEF HAD	IDEB Outcome
Calçoene		
Cutias do Araguari		
Ferreira Gomes		
Itaubal		
Laranjal do Jari		
Macapá		
Mazagão		
Oiapoque		
Pedra Branca do Amapari		
Porto Grande		
Pracuuba		
Santana		
Serra do Navio		
Tartarugalzinho		
Vitória do Jari		

Source: the authors.
AP: students per teacher; LEF: School with access to the energy network electrical and/or sewage system or septic tank; HAD: average daily class hours.

To represent infrastructure, the number of schools with access to electricity and/or sewage or septic networks (LEF) was used in proportion to the total number of schools in the municipality. Infrastructure is closely related to the efficiency of public spending on education. Therefore, including variables related to infrastructure helps clarify the process of generating inequalities that are reflected in differences in educational performance (Soares Neto *et al.*, 2013). Data on average class hours, electricity, and sewage or septic tanks were sourced from INEP microdata (Brasil, 2021a).

The output variable used was IDEB because it serves as a performance indicator developed to guide efforts in improving the quality of education. IDEB is derived from data collected through SAEB, *Prova Brasil*, and includes measures related to student progression and dropout rates, serving as a proxy for representing student learning. Since there is a lack of a comprehensive quality indicator that considers the complexities of the educational system, and IDEB is the most commonly used output variable by referenced authors, we chose to use this index as a proxy.

For this type of research, it is desirable to use historical data on inputs, as inputs applied in previous periods may influence the academic performance of students in subsequent years. However, it was not possible to use historical data in the present study. This is because IDEB is calculated biennially, in odd-numbered years. The IDEB data available for the even-numbered years in the dataset are repetitions of the previous year's data. On that note, the results presented in a given year are based on inputs from that year and the previous one.

The free software, Data Envelopment Analysis (Computer) Program (DEAP), was used for analysis, which uses balanced panels to perform the MPI analysis. In the panel of this research, some DMUs did not have data for all variables, with IDEB being the missing data in all occurrences: Itaubal and Serra do Navio in 2009 and 2010, Serra do Navio in 2011 and 2012, Cutias in 2015 and 2016 and Pracuuba in 2019. In these cases, the average of the IDEB results was used to fill in the gaps and balance the panel.

Banker *et al*. (1989) mentions the importance of respecting the degrees of freedom, so that the number of DMUs must be greater than three times the total number of variables (inputs and outputs), a requirement also known as the Golden Rule. However, the authors highlight that it is a practical rule, which can be adjusted in situations according to the researcher's expertise.

The stepwise method is a procedure in which the starting point is an initial pair of input and output and, little by little, variables are added with the analysis of the efficiency ranking for each variable entered (Wagner and Shimshak, 2007). The method was used to determine the variable with the lowest contribution to the model's efficiency. Fundeb transfers are a central point in this analysis, making it impossible to exclude them from the study. Thus, the variables that contributed least to the efficiency of the model in the ten years analyzed were GDP, together with the infrastructure variable, which refers to access to the network of electrical energy and/or the sewage network or septic tank (LEF).

Considering that the data for the 2019 GDP was not available at the time of data collection and that Fundeb is a central point in this analysis, with the availability of LEF data for all years showing considerable homogeneity and the relevance of the golden rule, it was decided to exclude GDP from the analysis. Therefore, four inputs were maintained: proportional transfer from Fundeb, students per teacher (AP), school access to the electricity network and/or sewage network or septic tank (LEF), average daily class hours (HAD), and one output variable: IDEB. In total, there are 5 variables for 16 DMUs.

RESULTS AND DISCUSSION

To present the results, a descriptive analysis of the data used in the present study was first be carried out. Averages and standard deviations were analyzed, per year, averages per municipality, and minimum and maximum values for the variables studied, year by year, and the behavior of some variables over time. Then, the changes in productivity between 2010 and 2019 will be identified, and the changes in technical efficiency and technological efficiency in this period and the trends imposed by the results found will be estimated.

DESCRIPTIVE DATA ANALYSIS

The preliminary analysis of the variables for each DMU showed that there is a significant dispersion of data related to Fundeb transfers and the number of students per teacher. When calculating the mean and standard deviation, numerous atypical values were identified for these two inputs.

The average Fundeb transfers, proportional to the 5th year, increased year by year throughout the entire period analyzed, except in 2018, which was the only year with fewer transfers when compared to the previous year throughout the entire ten-year period researched. Fundeb's average transfers increased by 300.65% from 2010 to 2019, with values adjusted by IPCA.

Regarding the number of students per teacher, the year with the highest average was 2010, with 50.18, and the year with the lowest average was 2019, with 29.70. From 2010 to 2019, the number of students per teacher reduced by 40.82%. However, there is considerable inequality, as some DMUs had low minimum values, such as Pracuuba in 2014, with only 15.42 students per teacher, while Mazagão had 139.67 students per teacher in 2012. This should not be discarded: the possibility of mistakes in statements made by managers who feed the INEP databases. However, considering the large period of time analyzed and the repeated exorbitant number of students in the same municipalities, it is necessary to reflect on the reasons for the overcrowding of classrooms highlighted in the descriptive analysis of the number of students per teacher.

The Federal Constitution (Brasil, 1988) grants legislative competence to member states to regulate education and authorizes the maximum number of students per classroom to be fixed by local law. The *Lei de Diretrizes e Bases da Educação Nacional* (LDB), a law that establishes the guidelines and bases of education, grants autonomy for the distribution of classes and students in state and municipal education networks by federated entities; therefore, there is no general rule that establishes a limit of students per classroom for municipalities (Brasil, 1996). In 2021, Bill 4731/2012 was approved to change the LDB with the aim of establishing a limit of 35 students in 5th-year elementary school classes, but the change is not yet in force, according to the News Agency of the Chamber of Deputies (Haje, 2021) (Table 2).

The State Law on Career Plans for Education Professionals in the state of Amapá establishes a limit of 25 students per class in the initial years of elementary school (Amapá, 2005). However, the justifications of the Bill itself for changing LDB mention non-compliance with state laws, and legal proceedings in the state Courts of Justice reveal that the problem of overcrowding of classes is a reality in Brazil.

However, no study was identified that compiles data regarding non-compliance with state laws. What is observed is the mismatch between legal determinations and the reality of municipal schools in terms of the number of students per class. While the change to LDB, applied to all federated entities, has not come into force, the search for compliance with state laws is fragmented into legal actions spread across state Courts of Justice.

It is worth noting that, despite the reduction in the number of students per teacher, there was an increase of 58.30% in enrollments in the period analyzed. Studies indicate that Fundeb was responsible for the growth in enrollments in the municipal education network, a phenomenon known as the municipalization of the supply of places in basic education, which was fundamental for the universalization of access to elementary education (Cury, 2018; Pinto and Alves, 2020).

This finding is consistent with the study by França and Gonçalves (2016), who pointed to Fundef as a stimulus for the decentralization of education, indicating a significant increase in the number of municipal schools. This helps to understand the role of Fundef and Fundeb in the municipalization of teaching in Brazil.

Table 2 – Means and standard deviations of inputs and output, by year, from 2010 to 2019

Year	Statistic	Fundeb D (R$)	AP	HAD	LEF	IDEB
2010	Mean	105,923.4	50.18	4.14	0.86	3.2
	Standard deviation	371,311.1	19.24	0.15	0.16	0.4
2011	Mean	110,253	49.79	4.12	0.87	3.7
	Standard deviation	370,846.9	25.48	0.14	0.14	0.4
2012	Mean	124,007.3	49.66	4.13	0.85	3.7
	Standard deviation	415,413.4	29.51	0.15	0.12	0.4
2013	Mean	148,662.1	38.74	4.12	0.89	3.5
	Standard deviation	486,670.6	18.35	0.13	0.10	0.5
2014	Mean	166,583.4	34.63	4.20	0.86	3.5
	Standard deviation	552,875.2	18.19	0.27	0.14	0.5
2015	Mean	168,960.1	31.23	4.17	0.84	3.8
	Standard deviation	580,660	11.65	0.15	0.14	0.4
2016	Mean	204,093.9	34.73	4.13	0.86	3.8
	Standard deviation	687,360	20.01	0.12	0.14	0.4
2017	Mean	241,024.3	33.64	4.14	0.85	3.9
	Standard deviation	830,371.6	14.74	0.14	0.13	0.6
2018	Mean	228,291.6	31.56	4.11	0.89	3.9
	Standard deviation	757,224.1	9.34	0.13	0.08	0.5
2019	Mean	252,364.6	29.70	4.13	0.87	4.2
	Standard deviation	843,536.7	11.63	0.16	0.15	0.4

Fundeb D R$: Fundeb proportional transfer deflated; AP: students per teacher; LEF: School with access to the energy network electrical and/or sewage system or septic tank; HAD: average daily class hours; IDEB: Basic Education Development Index (Índice de Desenvolvimento da Educação Básica).
Source: the authors.

As for daily class time, 2018 was the year with the lowest average number of class hours, with 4.11. In turn, 2014 was the year with the highest average, namely 4.20. There is a proximity between the lowest and highest averages per year, as indicated by the average standard deviation in the period, which is 0.15.

Table 3 shows the minimum and maximum values of each variable year by year, along with their respective DMUs. In cases where there are several DMUs with the same value, the number

Table 3 – Minimum and maximum input and output values, per year, from 2010 to 2019

Year		Fundeb D (R$)		AP		HAD		LEF		IDEB	
2010	Minimum	Pracuuba	425.35	Pracuuba	22.90	Six DMUs	4.00	Oiapoque	0.53	Amapá	2.6
	Maximum	Macapá	1,542,715.91	Mazagão	91.83	FourDMUs	4.30	Four DMUs	1.00	Macapá	4
2011	Minimum	Itaubal	390.73	Pracuuba	21.03	Eight DMUs	4.00	Laranjal do J.	0.57	Amapá	3
	Maximum	Macapá	1,543,250.22	Mazagão	126.25	Four DMUs	4.30	Four DMUs	1.00	Santana	4.8
2012	Minimum	Cutias	498.12	Pracuuba	16.43	Seven DMUs	4.00	Cutias	0.63	Amapá	3
	Maximum	Macapá	1,728,237.82	Mazagão	139.67	Two DMUs	4.40	Two DMUs	1.00	Santana	4.8
2013	Minimum	Cutias	424.82	Pracuuba	16.11	Seven DMUs	4.00	Mazagão	0.70	Tartarugalzinho	2.7
	Maximum	Macapá	2,024,336.56	Mazagão	89.50	Pracuuba	4.40	Five DMUs	1.00	Santana	4.6
2014	Minimum	Cutias	384.93	Pracuuba	15.42	Five DMUs	4.00	Santana	0.62	Tartarugalzinho	2.7
	Maximum	Macapá	2,301,080.85	Mazagão	91.33	Tartarugalzinho	5.10	Five DMUs	1.00	Santana	4.6
2015	Minimum	Serra do N.	204.09	Pracuuba	15.54	Five DMUs	4.00	Pedra B. do A.	0.57	Tartarugalzinho	3.1
	Maximum	Macapá	2,340,088.78	Macapá	58.05	Two DMUs	4.40	Two DMUs	1.00	Santana	4.6
2016	Minimum	Serra do N.	498.88	Pracuuba	16.41	Five DMUs	4.00	Macapá	0.49	Tartarugalzinho	3.1
	Maximum	Macapá	2,857,688.90	Mazagão	99.69	Three DMUs	4.30	Three DMUs	1.00	Santana	4.6
2017	Minimum	Cutias	446.32	Pracuuba	15.97	Seven DMUs	4.00	Ferreira G.	0.62	Pracuuba	2.7
	Maximum	Macapá	3,450,385.50	Mazagão	74.08	Five DMUs	4.30	Three DMUs	1.00	Serra do Navio	5.1
2018	Minimum	Cutias	707.47	Pracuuba	17.34	Nine DMUs	4.00	Amapá	0.69	Pracuuba	2.7
	Maximum	Macapá	3,147,762.41	Macapá	64.43	Four DMUs	4.30	Four DMUs	1.00	Serra do Navio	5.1
2019	Minimum	Serra do N.	1,336.36	Serra do N.	17.07	Eight DMUs	4.00	Vitória do J.	0.52	Calçoene	3.5
	Maximum	Macapá	3,507,313.29	Macapá	62.27	Serra do N.	4.50	Five DMUs	1.00	Macapá	5

Fundeb D R$: Fundeb proportional transfer deflated; AP: students per teacher; LEF: School with access to the energy network electrical and/or sewage system or septic tank; HAD: average daily class hours; IDEB: Basic Education Development Index (Índice de Desenvolvimento da Educação Básica).
Source: the authors.

of tied DMUs is indicated. It is observed that there is significant inequality between municipalities, primarily concerning the number of students per teacher. Regarding the difference related to Fundeb, it must be considered that the dimensions of the municipality affect the number of enrollments and, consequently, the total value of Fundeb for the 5th year. The percentage of schools with access to electricity and/or sewage or septic tank was the input that varied the least over time. The average standard deviation from 2010 to 2019 was 0.13. However, when looking at the table of minimums and maximums, it is noted that certain DMUs had very precarious infrastructure in certain periods, such as Macapá in 2016, with only 49% of schools having electricity and sewage or septic tanks, followed by Vitória do Jari in 2019, with just 52%.

As for IDEB, the year with the lowest average was 2010, with 3.20, while 2019 was the year with the highest average, at 4.22. There is an increasing trend in IDEB grades, which increased by 31.88% over the ten years analyzed, indicating an improvement in student performance in the tests used to calculate the index, along with a decrease in the number of failures and withdrawals (Table 4).

Table 4 – Average inputs and outputs, by municipality, from 2010 to 2019

Municipality	Fundeb D	AP	HAD	LEF	IDEB
Amapá	2,135.77	37.29	4.00	0.87	3.4
Calçoene	4,679.96	29.98	4.00	0.92	3.5
Cutias	614.47	39.46	4.04	0.85	3.2
Ferreira G.	4,655.97	24.51	4.27	0.87	3.5
Itaubal	1,252.29	31.69	4.16	0.89	3.7
Laranjal do J.	74,175.94	36.35	4.20	0.84	3.9
Macapá	2,444,286.02	64.61	4.19	0.84	4.3
Mazagão	12,429.60	86.78	4.05	0.87	3.4
Oiapoque	21,700.21	29.88	4.00	0.82	3.7
Pedra B. do A.	5,960.84	31.46	4.06	0.89	4.1
Porto G.	19,603.06	35.90	4.03	0.86	3.6
Pracuuba	1,307.86	17.46	4.32	0.85	3.3
Santana	186,004.66	46.50	4.28	0.88	4.6
Serra do N.	877.12	21.71	4.33	0.86	4.5
Tartarugalzinho	5,828.60	44.04	4.11	0.87	3.3
Vitória do J.	14,749.59	26.34	4.25	0.86	3.6

Fundeb D R$: Fundeb proportional transfer deflated; AP: students per teacher; LEF: School with access to the energy network electrical and/or sewage system or septic tank; HAD: average daily class hours; IDEB: Basic Education Development Index (Índice de Desenvolvimento da Educação Básica).
Source: the authors.

As for IDEB, the year with the lowest average was 2010, at 3.20, while 2019 had the highest average, at 4.22. There is an upward trend in IDEB grades, which increased by 31.88% over the ten years analyzed, indicating an improvement in student performance in the tests used to calculate the index, along with a decrease in the number of failures and withdrawals.

When analyzing public financing of basic education between 2007 and 2013, Oliveira (2015) identified a similar trend in which IDEB increased over time. The author states that the better redistribution of resources for education and the continuous increase in resources allocated to

Fundeb, when analyzed together with the increase in enrollment rates and the growth of IDEB, show that the fund's purpose is being achieved.

All municipalities had an increase in IDEB scores from 2010 to 2019, except for Pracuuba. The municipality with the lowest average IDEB scores over time was Cutias, with 3.2, and the one with the highest average was Santana, with 4.6. As for the proportion of Fundeb resources, Macapá received the most, while Cutias received the least. Regarding the number of students per teacher, Mazagão is the municipality with the highest average, at 86.78 students per teacher, and Serra do Navio has the lowest average, at 21.71. The average number of class hours for the entire state of Amapá remained between 4 and 4.32 hours. The municipality with the greatest access to electricity and/or sewage or septic tank was Calçoene, at 92%, while the one with the worst infrastructure was Oiapoque, with an average of 82%.

PRODUCTIVITY RESULTS

Total productivity (FTP) can be decomposed into TECH and EFF. EFF, in turn, can be decomposed into PE and SE. Therefore, productivity is composed of technological efficiency, pure technical efficiency, and scale efficiency. The difference between technical efficiency and pure technical efficiency is that in pure technical efficiency, there is no influence on the effect of the scale of production, while technical or productive efficiency is precisely the combination of pure technical efficiency and scale efficiency.

The average total factor productivity from 2010 to 2019 indicates an increase of 3.8% in total productivity, mainly due to a change in technological efficiency, which increased by 3.5%. Technical efficiency also grew, but to a lesser extent, by 0.3%, with 0.2% due to a gain in scale efficiency, and 0.1% due to a gain in pure efficiency.

The 3.5% increase in technological efficiency indicates a shift of the frontier, showing that the reference units exhibited greater productivity growth, positively advancing the frontier over time. The growth in technical efficiency was to a lesser extent, at 0.3%, suggesting that inefficient units approached the frontier, considering the displacement. This means that inefficient units moved closer to the frontier over time, even though there was a positive shift in the frontier.

The productivity results between 2010 and 2019 refer to the findings of Rosano-Peña, Albuquerque, and Daher (2012), who conducted a pioneering study in Brazil on the evolution of productivity and efficiency in municipal spending on elementary education in the state of Goiás during the years 2005, 2007, and 2009. Using MPI combined with DEA, they concluded that there was an increase in productivity levels due to a positive variation in productive efficiency and technological changes.

When looking at changes by municipality, considering the ten years analyzed, the municipality with the most significant change in total productivity was Amapá, with a 9.4% increase, driven by a 4.9% growth in technological efficiency and a 4.3% growth in technical efficiency. Pure technical efficiency increased by 4%, while scale efficiency only increased by 0.3%. The municipality of Oiapoque was the only one that presented a decline in productivity over the decade, at -2%, due to the reduction of both technological change by -0.02% and technical efficiency by -1.7%, resulting in a 2% reduction in scale efficiency, leaving only pure technical efficiency (Table 5).

Among all the municipalities analyzed, 15 showed productivity growth between 2010 and 2019, while only one showed a decline. In 12 municipalities, growth in total factor productivity occurred due to a shift in the frontier, meaning there was greater growth in technological efficiency. Among these, there were four cases of declining technical efficiency, indicating that the maximum efficiency frontier shifted positively, but the inefficient units did not follow, resulting in a gap between the units with maximum efficiency and the inefficient ones. Only three municipalities showed

Table 5 – Results of total productivity, productive, technological, pure, and scale efficiency, for each pair of years, between 2010 and 2019

Year	EFF	TECH	PE	SE	FTP
2010-2011	1.045	1.121	1.014	1.030	1.171
2011-2012	1.035	0.955	1.023	1.011	0.988
2012-2013	0.946	0.985	0.957	0.989	0.932
2013-2014	1.013	1.038	1.028	0.985	1.051
2014-2015	1.004	1.093	1.019	0.985	1.097
2015-2016	1.013	0.974	0.989	1.025	0.987
2016-2017	0.989	1.045	0.982	1.007	1.033
2017-2018	0.940	1.071	1.001	0.939	1.007
2018-2019	1.048	1.046	0.996	1.053	1.096
Mean	1.003	1.035	1.001	1.002	1.038

EFF: technical efficiency; PE: Pure Technical Efficiency; SE: Scale Efficiency; TECH: Efficiency Technology; FTP: Total Productivity.
Source: the authors.

growth in technical efficiency, indicating an alignment of units, with two of these showing a decline in technological efficiency.

MPI analyzes years in pairs, first comparing 2010 with 2011, then 2011 with 2012, and so on, using adjacent years, totaling nine analyses. In six adjacent years, there was growth in total productivity (2010-2011, 2013-2014, 2014-2015, 2016-2017, 2017-2018, and 2018-2019), primarily due to an increase in technological efficiency. In three of these pairs, there was a decline (2011-2012, 2012-2013, and 2015-2016), and again, technological efficiency had the greatest influence, but in this case, it was negative.

In the years 2010-2011, the total factor variation indicated a growth of 17.1%, making it the period of the greatest productivity gain when analyzing adjacent years. There was an increase in technological efficiency of 12.1% and in technical efficiency of 4.5%. Eleven municipalities showed a gain in productivity, while only five showed a loss, with Ferreira Gomes having the highest growth at 53.4%. In the years 2011-2012, there was a decline in total productivity, amounting to -1.2%, primarily due to a drop in technological changes of -4.5%. Laranjal do Jari was the municipality with the biggest drop in productivity, at -20.1%, mainly due to the relocation of the frontier, but there was also a reduction in the alignment of DMUs, indicating that inefficient municipalities moved away from those with maximum efficiency.

The period of the greatest decline in total productivity between adjacent years was 2012-2013, with a drop of -6.8%, primarily due to the greater influence of the decrease in production efficiency at -5.4%, while technological efficiency showed a decline of -1.5%. There was a loss of productivity in 11 municipalities during that period. The 5.1% growth in productivity in 2013-2014 was driven by the 3.8% shift in the frontier. Itaubal was the municipality with the greatest gain in productivity, at 32%, thanks to the alignment of DMUs, indicating that inefficient units moved closer to those that exhibited maximum efficiency.

The year with the highest number of municipalities showing productivity growth was 2014-2015, during which 13 units displayed an increase in productivity, with nine of them experiencing border relocation. Only three municipalities observed a decline in productive factors. Average productivity grew by 9.7%, primarily due to gains in technological efficiency. Pracuuba showed growth of 30.5%, also due to an increase in technological efficiency. Productivity declined by -1.3% in 2015-2016, primarily due to a shift in the frontier of -2.6%. This indicates that the efficiency frontier moved from one year to the next, suggesting a decline in technological efficiency, despite an increase in technical efficiency of 1.3%. Nine municipalities experienced a drop, with Pedra Branca do Amapari displaying -13.6% in total productivity, also due to the border movement.

The 3.3% growth in productivity factors in 2016-2017 was primarily due to the 4.5% growth in technological efficiency, despite a reduction in technical efficiency, indicating that inefficient units moved away from the frontier. Itaubal was the municipality with the highest growth, at 31.1%, driven by a match of 16.2%. The 0.7% growth in 2017-2018 was partially caused by the 19.8% growth in Serra do Navio, which experienced a significant border shift. During this period, ten municipalities showed growth, while six decreased.

The last period analyzed was 2018-2019, which saw 12 municipalities with productivity growth. Total factor productivity increased by 9.6%, with a growth of 4.8% in technical efficiency and 4.6% in technological efficiency. This indicates that, despite a positive shift in the frontier, the inefficient municipalities managed to get even closer to it, thanks to a significant increase in technical efficiency.

When observing the behavior of productivity in the nine adjacent years analyzed, there was growth in six periods, while only three showed a decline in productivity. Thus, even though significant growth like that of 2010-2011 was not identified, there was productivity growth in 66.7% of the periods analyzed, while only 33.3% of the analyzed intervals showed a decline in productivity.

CONCLUSION

This work aimed to analyze the productivity of education expenditure related to resources from Fundeb, focusing on the 5th year of primary education in schools within the municipal administrative network/dependency of the state of Amapá, during the years 2010 to 2019, using panel data. The specific objectives included conducting a descriptive analysis of the data, identifying changes in productivity between 2010 and 2019, pinpointing the municipalities with the best and worst productivity results, examining changes in technical (productive) efficiency and technological efficiency, and estimating trends based on the results obtained.

Preliminary analysis of the data confirms the initial assumption for preparing the study, which is the presence of inequality between federative units, with disparate values for each of the variables studied, even with a sample of a state with a limited number of municipalities. The minimum and maximum values for each DMU studied demonstrate that efforts are still needed to reduce the disparities in capital, labor, average time spent at school, and infrastructure among different municipalities. Despite this inequality, it was observed that IDEB scores gradually improved by 31.88% over the ten years analyzed.

In terms of productivity analysis, growth in productivity was identified in the allocation of educational resources, with increases in technological efficiency, technical efficiency, pure technical efficiency, and scale efficiency.

There was growth in technical efficiency, indicating the approach of the analyzed units to the efficiency frontier, and in technological efficiency, indicating the displacement of the frontier. In this way, even though the efficiency frontier moved positively, the inefficient units managed to get closer to the units with maximum efficiency.

The behavior of productivity in adjacent years indicated a decline in three periods, while there was productivity growth in six adjacent years.

In the ten years analyzed, there was an increase of 3.8% in total productivity, resulting from a positive evolution in technology of 3.5% and a change in production efficiency of 0.3%. The municipality with the most significant change in total productivity over the entire decade was Amapá, at 9.4%, while the municipality of Oiapoque was the only one that showed a decline in productivity, amounting to -2%.

It is considered that the analyses presented in this study can provide support for public policies in Amapá, especially in areas where a decline in productivity was identified throughout the decade analyzed. The state of Amapá is relatively under-studied, and the analysis presented in this article can be a significant contribution to gaining a deeper understanding of data on public educational policies and contributing to a better understanding of inequalities and challenges for education in Brazil. The work can also provide important references for future comparisons once New Fundeb is fully implemented.

The DEA method and MPI can be used to analyze other FNDE educational programs, such as the National School Food Program and the National Textbook Program. Innovations in methodology and the use of logistic regressions can contribute to a better understanding of educational policies.

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ABOUT THE AUTHORS

CECÍLIA CALCAGNO GRILLO has a master's degree in Public Management from Universidade de Brasília (UnB). She is a Specialist at Fundo Nacional de Desenvolvimento Educacional (FNDE).

CELSO VILA NOVA DE SOUZA JÚNIOR has a doctorate in Economics from Universidade de Brasília (UnB). He is a professor at Universidade de Brasília (UnB).

TITO BELCHIOR SILVA MOREIRA has a doctorate in Economics from Universidade de Brasília (UnB). He is a full professor at the Getúlio Vargas Foundation, School of Public Policies and Government (FGV EPPG).

CÉSAR AUGUSTO DE SOUZA PINTO GALVÃO is graduating in Statistics from (UnB). He is an Analyst at Nacional de Administração Pública (ENAP).

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