Revista de Educação e Pesquisa em Contabilidade
Journal of Education and Research in Accounting
Revista de Educación e Investigación en Contabilidad

REPeC, Brasília, v. 9, n. 3, art. 4, p. 285-301, Jul./Sep. 2015
Available online at *www.repec.org.br*
DOI: http://dx.doi.org/10.17524/repec.v9i3.1230

Quarterly journal, digital and free published by Brazilian Academy of Science in Accounting
ISSN 1981-8610

Level of Technical Efficiency of Federal Institutes of Education, Science and Technology and the Relation Between Costs, Indicators of Expansion and Retention in Efficiency Scores

Abstract

This study aimed to identify the technical efficiency scale of the Federal Institutes of Education, Science and Technology and the relation among the costs, indicators of expansion and retention in the efficiency scores, comprising the period 2012-2013, totaling a sample of 19 units. To verify the technical efficiency and the possible variables that influence the institutes considered efficient and non-efficient, the indicators elaborated by the Secretary of Professional and Technological education (Setec) were used, established by the TCU and annually presented in the Accountability Report. The efficiency result demonstrates that only 31% (n = 6) of the institutes analyzed reached the efficiency score in 2012 and 2013. There is evidence that the institutes considered efficient presented better mean better results of graduates per enrolled students and lower current spending per enrolled students, indicating that obtaining results is not conditioned to further spending.

Key words: Public expense. Professional education. Data envelopment analysis.

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Published in Portuguese, English and Spanish. Original Version in Portuguese.

Received in 3/10/2015. Ask to Revise on 5/24/2015. Resubmitted on 7/1/2015. Accepted on 8/4/2015 by Dr. Valcemiro Nossa (Editor). Published on 9/30/2015. Organization responsible for the journal: Abracicon.

1. Introduction

Considering the theory that resources employed in individuals are important forms to promote the social and economic development of a State, the concept identified as the theory of Human Capital was explored to prove that individuals are investments that absorb the education factor and support the growth of a country (Schultz 1960, 1961, 1962; Mincer, 1958; Becker, 1960). It is the consideration that the knowledge individuals acquire lever the development of a country (Schultz, 1961).

Thus, investments in education are important to discover the junction between the theory of Human Capital and the policies of a state. In Brazil, the Federal Constitution of 1988 treats Education as a fundamental right of all. The text divides the responsibility among the Union, states and cities, ranging from basic to higher education and their extensions, linking taxes and contributions from society to the development of teaching (Constituição da República Federativa do Brasil de 1988, 2001).

Particularly in Professional and Technological Education (EPCT), as a State Policy (Pereira, 2003; Pacheco, 2009), in 2008, except for some Federal Technological Education Centers, the Law on the Federal Network of Professional, Scientific and Technological Education was introduced, linked to the Ministry of Education, consisting of 38 Federal Institutes of Education, Science and Technology, or simply Federal Institutes (FI), increasing their activity beyond professional and basic education, including higher education, research and community services (Law No. 11. 892, 2008).

The education area has different inputs and products that can be explored to measure the efficiency of teaching institutions. That is, social and financial characteristics, properties of products produced, among others, can contribute to disclose the performance. These aspects are import sources of measures that can lead to explanations about the students' results, using resources directed at the education area and at the relevance found in the policies, aiming for the quality of teaching (Hanushek & Luque, 2003; Hanushek & Raymond, 2005).

This efficiency is called "technique", also identified as "productive" efficiency (Belloni, 2000; Costa, Ramos & Souza, 2010) as, in the public education area, no market value has been found for the products generated, but a limitation of resources found for the production of possible results for that production.

Nevertheless, to verify the performance of the Federal Institutes, the Secretary of Professional and Technological Education formulated different indicators, instituted by the Federal Audit Court. One may say that what they intend to verify is the presence of accountability and its good practices, sought in the public area to clearly present the role of management, prioritizing the duty of the managers to deliver accounts (Kluvers, 2003; Kaldor, 2003; Koppell, 2005). Accountability is identified as a process similar to "accountability" by the actions of the Federal Audit Court.

In that contexto, it is important to evidence the materialization of the delivery of the results achieved to society, the investments made and the performance in the policies elaborated to attend to a social need.

The availability of studies whose results are useful to the public management and project the analysis of economicity, efficiency and efficacy of the financial and economic factors, it is essential to distribute safe and transparent information in society. It includes the practice of governance, as objectives are outlined and achieved through actions that require periodical knowledge of the activities adopted with performance assessment. Hence, this study aims to answer the following inquiry:

What is the technical efficiency scale of the Federal Institutes of Education, Science and Technology and the relation of the costs, indicators of expansion and retention in the efficiency scores?

To be presented, this scale is the classification of the units considered efficient and non-efficient, as to the use of the tool Data Envelopment Analysis (DEA), which generates technical efficiency scores.

To develop the study, in section 2, the Theoretical Framework is presented with the discussions, involving Investments in Education and Student Performance, the Federal Network and the Policies of Professional and Technological Education and Technical Efficiency. In section 3, the research method will be discussed, ending with the results found and the final considerations.

2. Literature Review

2.1 Investments in education and student performance

The resources transmitted by the Government for education through public policies are discussed in the Theory of Human Capital developed by Schultz (1960, 1961 and 1962), Becker (1960) and Mincer (1968), who consider that investments in the area on the citizens lever the development of a State.

In Brazil, the right to education is listed in the chapter of the 1988 Brazilian Constitution (Constituição da Republica Federativa do Brasil de 1988, 2001) about "fundamental rights". The division of the public resources to be employed in education is also imposed, higher education being the responsibility of the Federal government, as well as the redistributive and supplementary function. The cities are in charge of basic education, and childhood education and state governments are responsible for secondary and primary education.

Concise data are needed about the nature of the educational policies and the returns for society and the economy of that country. It is not enough to increase the resources invested and not to know its efficiency for the students' results (Hanushek, 1989).

What is most perceptible in the literature on resources and performance is the fact that the former can influence the incentives for the education area, with impacts in the results for the students. Thus, the increase of the teachers' salaries and the decrease in the number of students in classes, in developed countries as well as in developing countries, influence the students' performance. These are discoveries that can guide the actions to increase the quality of teaching (Hanushek & Woessmann, 2007).

Hanushek and Luque (2003) discuss that the family aspects are also important sources of information to understand the students' learning and their level of performance. Becker (1960) inquires that investments in education are a social return, to the extent that it can increase a country's income. When the skills and the level of education are high, the individual gain becomes greater than people without these requisites (Mincer, 1958). Schultz (1961, p. 02) considers that "By investing in themselves, the people can expand the range of options available to them. It's a way for free men to be able to improve their wellbeing".

The objective of performance analysis is to provide data that can support the policies focused on the teaching area, as it discusses whether the education is efficiently collaborating to the civil development and whether the inputs are truly leading to outputs of qualified products. It is the production function acting in the structure of education (Hanushek, 1989; Hanushek & Luque, 2003; Hanushek & Raymond, 2005).

A research undertaken in the United States in the 1990's by Hanushek and Raymond (2004), using the grades of students who took the National Assessment of Educational Progress (Naep) highlights that having an accountability system is positively related to the students' performance and that, when there are several objectives to be achieved, a larger number of policies should be elaborated so that these objectives are not concentrated in a sole action, thus limiting the achievement of the expected results. Carnoy and Loeb (2002) elaborated a research in which the exams taken between 1996 and 2000 in the same place were related, showing a positive association between states with a higher degree of accountability and the students' performance.

It is important to highlight that the accountability system in schools in the United States adopts the incentive policy as one of the strategies to obtain results. Hanushek and Woessmann (2007) advocate that creating incentive mechanisms for teachers can be a strong point in performance improvement in schools.

In the context of developing countries, the research by Álvarez, Moreno and Patrinos (2007), in Mexico, highlights the importance of accountability in teaching, besides the union power and the schools' decentralization and autonomy.

In performance analysis among public and private school users in primary education, in 20055, Oliveira, Belluzo and Pazello (2009) found in their research that the schools' structure and the teachers' education and experience are variables related to the schools' performance.

2.2 The federal network and the professional and technological education policies in Brazil

Professional education originated in the need to attend to the least favored, creating tasks for them, with a view to having not only primary, but also higher education in the future.

Over time, these institutions transformed from the School of Apprentices and Workmen in 1909, under the government of Nilo Peçanha, to the Industrial Lycea in 1930 and Technical Schools as early as in 1942. Later, in 1942, the transformation to Federal Technological Educaiton Centers took place and, in 2008, they were institutionalized as Federal Institutes of Education, Science and Technology, offering primary, technical and higher education in their structure.

In 2005, the professional education policies were included in the Expansion Plan of the Federal Network of Professional and Technological Education. In 2007, the Ministry of Education launched the Plan for the Development of Education (PDE), which includes the Federal Network as a proposal for expansion, with several institutions that would be part of this network, aiming to disseminate professional and technical knowledge in different regions, proposing technological innovation and applied research according to the particularities of each region (Pereira, 2009).

The introduction of new federal institutes and new institutions in the different microregions addressed in the expansion program of the Federal Network demonstrates the importance the State attributes to the verticalization of teaching, to grant access to education to everyone, and also to the way technical and professional education is being conducted, as this policy is linked to the current government as well as to other governments that can aim for the continuity of education constructed inside institutions. It is the way found to internalize the courses that only used to be found in few places, mainly concentrated in the capitals.

Thus, the multicampi structure and the verticalizaiton of teaching are characteristics aimed not only at educating individuals, but also at regional development, to the extent that it aims to attend to local technical and technological needs, creating research to be applied and to support sustainability in the region. In that context, articulation among teaching, research and community services is important, as drivers of the development policies in the different places and of social inclusion (Pacheco, 2009).

In addition, there is the fact that the Institutes are devised as strategic projects to equally reach those individuals who did not participate in the development of Brazil earlier and who are considered important actors for professional and technological education (Law No. 11.892, 2008).

Thus, professional and technological education, considered as a public policy whose structure contains network thinking, establishes communication with the different sectors and social actors present in the regions, as vehicles the Government uses to be able to attend to the local needs and link the extent of teaching to the actors involved, to technical and technological development and to social development.

2.3 Technical efficiency

Emphasizing the economic approach to efficiency, although closely linked to the efficacy concept, according to Matei and Savulescu (2009), there is the distinction of two types: technical efficiency and allocative efficiency. The first, according to Diniz (2012), is based on the processes for the production of goods or services. That is, through the analysis of the processes to produce the end product, it can be verified whether the resources were allocated efficiently or not. The second "measures the ability of an entity to choose excellent input proportions, in which the index between the marginal product values of each pair of inputs equals the index of its market prices", demonstrating profit as an important factor to measure efficiency (Diniz, 2012, p. 76).

Thus, what is observed in professional and technological education is the range of technical efficiency, as the resources employed for the development of education in the Federal EPCT Network are limited by the public budget. It takes effort to maximize the products produced with the resources employed, and not the opposite.

Focusing the analysis on technical efficiency in education, studies on the area aim aim to identify the existing relation between the inputs and the outputs. These inputs can be the teachers' characteristics, the physical facilities, spending on human resources, among other characteristics that require monetary values. The outputs, as the environment of education is non-for-profit, like in a company, their identification may be somewhat difficult. Pritchett and Filmer (1997) defend the approach of a behavioral theory on the inputs involved in the production function, like the teachers for example.

In the survey by Cordero, Pedraja and Salinas (2008), in Spain, to verify the best model to measure the production, the students' grades on the entry exam were used as the output variables; the number of teachers for every 100 students and costs on students and staff, both controlable, were used as input variables; and, as non-controllable input variables, socioeconomic data, data about the family and skills and influences from classmates. The authors highlight that there does not exist a model that is better than the other, but the sample that is available, linked to the research objective.

In the research by Diniz (2012) on public transfers to the cities and primary education, inputs were used, cost per student and the Development Index of Basic Education (Ideb) as products of education. Evidences were found that the most efficient cities have a higher cost per students, higher development indices of basic education and a larger number of enrolled students.

The structure employed by Oliveira and Turrione (2006) investigated the Federal Higher Education Institutions (Ifes), using the Capes/MEC concept and the success rate in undergraduate education as the outputs. Among the findings, it is highlighted that the Data Envelopment Analysis (DEA) permits support for the setting of targets that contribute to the achievement of efficiency improvements.

Another study, based on Hernández' (2004) definitions about indicators, also assessed higher education institutions with the same outputs but, as inputs, the current costs per student, fulltime students per equivalent employee and the qualification index of the teaching staff were used. The results indicate that, over time, there may be a decrease in the educational product (Costa, Ramos & Souza, 2010). In addition, Hernández highlights that the variable "Number of graduates" can be used as an output in efficiency analysis.

In their study, Freire, Crisóstomo and Castro (2007) used the indicators of higher education performance assessment established by the TCU, in a sample of 27 institutes in 2005, found a favorable result between the number of students and employees, but did not detect a positive relation between the cost per student and their performance.

In the research by Oliveira (2013), which analyzed whether the Reuni program influences the efficiency of Federal Higher Education Institutions (Ifes), covering the periods from 2006 till 2007 and from 2008 till 2012 and using the indicators presented to the TCU. The products were the Capes concept and the undergraduate success rate. The findings showed that efficient Ifes considered efficient as a whole have a good supply and structure of *stricto sensu* graduate programs, with a larger number of degrees issues during that years.

3. Method

In this phase of the study, the technical efficiency scores were obtained, identifying the efficient and non-efficient Federal Institutes through the product-oriented DEA/BBC model. Thus, to be considered efficient, the score of the Institute should be equal to 1 (one).

The Decision Making Units (DMUs) were presented, which are benchmarks for non-efficient Federal Institutes. Descriptive statistics were used to visualize the variables' behavior in the Data Envelopment Analysis. To avoid collinearity problems, the correlation analysis between the variables was applied.

And, finally, using the Tobit method, the relation "Income per enrolled students" and "Retention index" influences the Federal Institutes' efficiency.

3.1 Research data

To execute this research, the Federal Institutes of Education, Science and Technology were chosen. The study period includes 2012 and 2013. The main research incentive is the fact that the Institutes have been created as from 2008, through the enactment of Law 11.892 on December 29th 2008.

The databases came from the websites of the Federal Institutes and, when not found, further data were sought on the website of the Federal Court of Auditors. To measure the efficiency, the Deap (Data Envelopment Analysis Program) system version 2.1 was used.

Although the Federal Network of Education, Science and Technology was created in 2008, the information to elaborate the indicators for that year were only available in 2009. On the other hand, in 2009 and 2010, some institutes did not present data or incompletely, motivated by the construction of the physical infrastructure for the institutions' core activities. This negatively affected the selection process for new students. Finally, 2011 was not considered in the analysis as, due to the change in the computer system Setec used in 2010, the data of some campi were damaged during the migration.

After defining the data, the next step was to identify possible discrepant variables that could interfere in the behavior of the findings.

The years 2012 and 2013 were analyzed separately and jointly, with a view to observing probable outliers and treat them when necessary. In this case, the procedure was applied to the output "Relation between graduates and enrolled students" and the inputs "Current spending per enrolled student", "Degree index of teaching staff" and "Number of students per teacher". After verifying the institutions, the standardized score test (Z-test) was applied to identify whether, among the federal institutes in the research, there are scores higher than three (Levine, Berenson & Stephan, 2011, p. 99).

Based on the Z-test procedure, the Instituto Federal Norte de Minas Gerais was excluded from the sample, due to the presence of more than three standard deviations for the variables "Current cost per enrolled student" and "Number of students per teacher".

The number of federal institutes used in the research has been indicated in Table 1, after collecting information from the Annual Accountability Reports and after treating for outliers.

Table 1
Final sample with total number of Federal Institutes used in the research

Initial population	(+) 38 Institutes
FI without complete information	(-) 18 Institutes
FI with outliers	(-) 01 Institute
Total Institutes used	= 19 Institutes

Source: elaborated by the authors.

3.2 Calculation of technical efficiency

The first discussion about the Data Envelopment Analysis (DEA) technique came from Farrell (1957). Next, the work by Charnes, Cooper and Rhodes (1978) can be cited, which disseminated the practice. To choose the DEA model, the researcher needs to define the Decision Making Unit (DMU) to be explored and the variables to be inserted. In this case, the DMUs should be comparable, acting under the same conditions, and the inputs and products should be the same, differing in the intensity and magnitude of the observed values. The models employed are known as CRS – Constant Returns to Scale and VRS – Variable Returns to Scale. The first was introduced by Charnes, Cooper and Rhodes (1978) and the second in the study by Banker, Charnes and Cooper (1984).

The BCC model (Banker, Charnes & Cooper, 1984) is the most indicated for this research, as it considers the variable scale returns and fits into the calculation of the institutes' efficiency, as it is appropriate to units of distinct dimensions (Belloni, 2000). Considering the study by Kassai (2002), the product-oriented BCC model that will be used in the research is mathematically formulated as follows:

$$\text{Minimize} \sum_{i=1}^{n} v_i \, x_{ki} + v_k \tag{01}$$

Subject to

$$\sum_{r=1}^{m} u_r \, y_{rk} = 1 \tag{02}$$

$$\sum_{r=1}^{m} u_r \, y_{jr} - \sum_{i=1}^{n} v_i \, x_{ji} - v_k \leq 0 \tag{03}$$

$$u_r, v_i \geq 0 \tag{04}$$

$$y = products; \;\; x = inputs; \;\; u, v = weights$$

$$r = 1, \dots, m; \;\; i = 1, \dots, n; \;\; j = 1, \dots, N$$

The term v_k can be negative or positive as it represents the possible return of variable scales. The efficiency indicator of the BCC model is the technical efficiency model (Kassai, 2002). Due to the combination between the mix of inputs and products used in Data Envelopment Analysis, one can reach frontline technical efficiency and be classified among the institutions scoring 1 (one), that is, efficient, and institutions scoring less than 1 (one), which are not efficient.

3.3 Variables used to calculate the DEA

In the studies involving Data Envelopment Analysis, there exists an empirical recommendations that states that "the number of DMUs should contain at least the double or triple of the number of variables" (Gomes, Mangabeira, & Soares de Mello, 2005, p. 613). In this study, there are four variables and 19 DMUs. Table 2 details the variables and their concepts for the inputs and the output to be inserted in the efficiency analysis.

Table 2
Inputs and output

Inputs			
Indicator	**Operationalization**	**Calculation terms**	**Objective and Theoretical Platform**
Current spending per enrolled student	$GCA = \frac{\text{Total spending}}{\text{Enrolled students}}$ (05)	Total spending / Enrolled students	Measure how much an enrolled student costs per year. Used by Oliveira and Turrioni (2006), Freire, Crisóstomo and Castro (2007), Costa, Ramos and Souza (2010), Oliveira (2013).
Degree index of teaching staff	$ITD = \frac{G \times 1 + Q \times 2 + S \times 3 + M \times 4 + P \times 5}{G+Q+S+M+P}$ (06)	Degree of teaching staff (G x 1 + Q x 2+ S x 3 + M x 4 + P x 5) / Sum of teachers (G + Q + S + M + P)	Measure of technical quality of teaching staff, applying weights ranging from 1 to 5. Used by Hernández (2004), Oliveira and Turrioni (2006), Freire, Crisóstomo and Castro (2007), Costa, Ramos and Souza (2010), Oliveira (2013).
Relation number of students per teacher	$RPA = \frac{\text{Number of enrolled students}}{\text{Full-time teachers}}$ (07)	Enrolled students /	Measure of number of students attended by a certain number of teachers. Used by Hernández (2004), Oliveira and Turrioni (2006), Freire, Crisóstomo and Castro (2007), Costa, Ramos and Souza (2010), Oliveira (2013).
Output			
Indicator	**Operationalization**	**Calculation terms**	**Objective and Theoretical Platform**
Relation graduates per enrolled student	$RCM = \left(\frac{\text{Number of graduates}}{\text{Enrolled students}}\right) \times 100$ (08)	Graduates / Enrolled students	Verifies the number of graduates in the different coruses. It is the delivery of the end product. Similar to studies by Hernández (2004), Costa, Ramos and Souza (2010), Oliveira (2013).

Legend: Total spending = Total spending excluding investments, court orders, inactive and retired; Enrolled students = total number of students enrolled at the institution; Degree of teaching staff = classified in 5 subgroups: Graduated, Qualified, Specialist, Master's and Ph.D., to which the weights 1, 2, 3, 4 and 5 are attributed, respectively; Sum of teachers = Sum of total number of graduated, qualified, specialized, Master's and Ph.D. teachers; Full-time teacher = Total number of teachers working 20 hours and multiplied by 0.5 (zero point five) plus the total number of teachers working 40 hours plus teachers working on an exclusive dedication regimen; Graduates = Total number of students who completed the credits and are ready to graduate.

Source: elaborated by the authors.

3.4 DEA Model

In the DEA analysis, the discretionary variables were inserted, distinguishing the inputs the manager influences. Thus, the DEA model is specified below:

$$\theta_{it} = f\,(Outputs\ (graduate_{it}),\ Inputs\ (discretionary_{it})) \tag{09}$$

Where:
θ_{it} – efficiency of institute *i* in year *t*
$Graduate_{it}$ – relation graduates and students enrolled at institute *i* in year *t*
$Discretionary_{it}$ – current spending per student,degree index of teaching staff and relation students per teacher at institute *i* in year *t*

3.5 *Tobit* model

To explain the variables related to the efficiency scores, the Tobit regression was applied, which uses the maximum likelihood method, as the estimation using the Ordinary Least Squares (OLS) method was not possible. According to Gujarati (2006, p. 497), in case of trunked data, there may be tendentious and inconsistent estimators. In other words, in this research, as the efficiency scores are trunked to the right $\theta_1 = 1$, the most appropriate is to apply the tobit method because the efficiency scores in the elaboration of the DEA are not higher than 1 (one).

Thus, a regression was applied with the independent variables, the relation new students per enrolled student and the school flow retention index, with the scores calculated using Data Envelopment Analysis serving as the dependent variable.

The indicator "Relation new students per student" is highlighted as important to verify the expansion of teaching, bconsidering that the institutions' objective is to use the limited inputs to obtain a greater return. Thus, the expected signal for these variables is positive. The "School Flow retention index" on the other hand, is based on the fact that the students who should graduate within the projected period were unable to conclude their academic activities, and were therefore retained at the Federal Institute. In other words, if the objective, in this case, is to produce the product "graduate" within the expected period to conclude the course, higher numbers of retained students may mean a lower number of graduates (Dias, Cerqueira & Lins, 2009). Hence, a negative signal is expected.

The empirical model, in this case, establishes the indicators in the Manual of the EPCT Network as the independent variables, including the definitions presented earlier:

$$\delta_i = \beta_1 + \beta_2 RIA_{it} + \beta_3 IFE_{it} + \omega_{it} \tag{10}$$

Where:
δ_{it} – adjusted efficiency score of institute *i* in year *t*
RIA_{it} – relation new students per student at institute *i* in year *t*.
IFE_{it} – school flow retention index at institute *i* in year *t*.

The indicators to be integrated into the model and its definitions have been listed in Table 3.

Table 3
Independent variables

Indicator	Operationalization	Calculation terms
Relation new students per student (RIV)	$RIV = \left(\frac{\text{Number of new students}}{\text{Enrolled students}}\right) \times 100 \quad (11)$	$\frac{\text{Number of new students}}{\text{Enrolled students}}$
School flow retention index (IFE)	$IFE = \left(\frac{\text{Number of retained students}}{\text{Enrolled students}}\right) \times 100 \quad (12)$	$\frac{\text{Number of retained students}}{\text{Enrolled students}}$

Legend: Number of new students = Total new students through entry exam, selection processes or other forms of entry; Enrolled students = Total enrolled students at the institution; Number of retained students = Total of a given enrollment cycle considered active, graduate or fully integrated school phase.

Source: elaborated by the authors.

4. Results and Discussion

4.1 Technical efficiency

The descriptive statistical results suggest a variation in the resources allocated to the institutions (current spending per enrolled student) when observing the maximum and minimum amount of resources received in that year, in 2012 as well as 2013. The reason for this occurrence may be related to the budgetary structure of the federal institutes, developed according to the actual number of enrollments. As to the variable "Degree index", between 2012 and 2013, the minimum "qualification index" increased from 2.09 to 3.06, which can reveal that this index is increasing in the units analyzed.

Table 4
Descriptive statistics DEA

	GCA	ITD	RPA	RCM
Institutes – 2012	**19**	**19**	**19**	**19**
Mean	7,931.83	3.46	27.27	12.24
Standard deviation	1,563.19	0.58	5.32	5.59
Minimum	5,482.86	2.09	21.07	3.77
Maximum	11,498.72	4.6	37.38	25.79
Institutes – 2013	**19**	**19**	**19**	**19**
Mean	9,687.11	3.63	27.9	12.58
Standard deviation	2,106.37	0.43	5.42	5.19
Minimum	7,345.24	3.06	19.6	3.87
Maximum	13,844.08		38	23.89

Where: RCM = graduate students/enrolled students; GCA = total spending /enrolled students; ITD = number of teachers per qualification level multiplied by respective weight/total number of students; RPA = enrolled students/ number of fulltime teachers.

Source: elaborated by the authors.

As to the correlation analysis, no coefficients higher than 80% were found, which would entail greater collinearity problems (Gujarati, 2006, p. 289). Only the variable "Current spending per enrolled student (GCA)" showed positive statistical significance in the "Degree index of teaching staff (ITD)", around 43.9%, and negative statistical significance with "Relation number of students per teacher (RPA)", corresponding to 56.4%.

To develop the DEA, the research employed the *log* function in the variables used in this study, in which the function returns to the cumulative log-normal distribution of x, where ln(x) is normally distributed with "Mean" and "Standard deviation", so as to avoid heteroscedasticity problems of the variables.

4.2 Calculation of technical efficiency scores

Pursuing the analysis, in Table 5, the efficiency scores of the Institutes are distinguished.

Table 5

Efficiency scores for 2012 and 2013

Institute	Efficiency – 2012	Benchmark	Efficiency – 2013	Benchmark
Amazonas	0.764	Roraima, Maranhão	0.754	Maranhão, Santa Catarina
Brasília	**1.000**	Brasília	**1.000**	Brasília
Ceará	0.520	Maranhão	0.733	Maranhão, Santa Catarina e Espírito Santo
Esp. Santo	0.862	Maranhão	**1.000**	Espírito Santo
Farroupilhas	0.788	Maranhão	0.858	Santa Catarina, Espírito Santo
Fluminense	0.788	Maranhão	0.964	Santa Catarina, Maranhão
Goiano	0.757	Maranhão	0.728	Santa Catarina, Espírito Santo
Maranhão	**1.000**	Maranhão	**1.000**	Maranhão
Mato Grosso	0.665	Maranhão	0.893	Espírito Santo, Maranhão e Rio de Janeiro
Minas Gerais	0.886	Maranhão	0.911	Espírito Santo, Santa Catarina
Rio Grando do Norte	0.905	Maranhão	0.812	Maranhão, Santa Catarina e Espírito Santo
Rio Grande do Sul	0.828	Roraima, Maranhão	0.930	Espírito Santo, Santa Catarina e Maranhão
Rio de Janeiro	**1.000**	Rio de Janeiro	**1.000**	Rio de Janeiro
Rondônia	**1.000**	Rondônia	0.461	Maranhão,Santa Catarina
Roraima	**1.000**	Roraima	0.615	Maranhão, Santa Catarina e Espírito Santo
Santa Catarina	0.946	Maranhão, Roraima	**1.000**	Santa Catarina
Sergipe	0.409	Maranhão	0.605	Maranhão, Santa Catarina e Espírito Santo
Tocantins	**1.000**	Tocantins	**1.000**	Tocantins
Triângulo Mineiro	0.918	Rondônia, Roraima	0.831	Maranhão

Source: elaborated by the authors.

In 2012, it can be observed that the Federal Institutes in Brasília, Maranhão, Rio de Janeiro, Rondônia, Roraima and Tocantins achieved efficiency, that is, 31% [$n = 6$] in the period, as they obtained an efficiency score of 1 or 100%. Considering that the technique is product-oriented, the result indicates that, for the mix of inputs used, these Federal Institutes used their resources efficiently. In addition, as their results reached an efficiency socre of 1 or 100%, they can be considered as models for the other institutes that did not achieve full efficiency, that is, benchmarks for non-efficient institutes.

To understand the use of the benchmark, it is sufficient to observe, for example, the FI Sergipe, which obtained the lowest efficiency score, should be guided by the Instituto Federal do Maranhão to be able to obtain better efficiency results. Hence, in 2012, the non-efficient units should be guided by their respective benchmarks to achieve better efficiency.

In 2013, the Federal Institutes that achieved efficiency were located in Brasília, Espírito Santo, Maranhão, Rio de Janeiro, Santa Catarina and Tocantins, also 31% [$n = 6$], with scores equal to 1 or 100%. It is highlighted that the institutes in Brasília, Maranhão, Rio de Janeiro and Tocantins are still considered efficient in comparison to the year previously analyzed (2012). As to the benchmarks identified, the units that stood out were Santa Catarina and Maranhão.

To more specifically analyze the costs per student enrolled and deepen the analysis about the efficiency scores, the mean scores were separated into quartiles. In this case, the comparisons are based on the first quartile, which corresponds to 25% of the federal institutes that obtained the worst efficiency scores, and on the federal institutes that surpass the third quartile and correspond to 25% of those considered efficient, as shown in Table 6:

Table 6
Characteristics of efficient and non-efficient federal institutions

Year	Position measure	Score	GCA	ITD	RPA	RCM
2012	1st quartile	0.6278	9,139.01	3.68	24.87	8.52
	3rd quartile	1	7,068.40	2.89	26.53	12.97
2013	1st quartile	0.6284	10,113.72	3.42	28.46	6.75
	3rd quartile	1	9,626.30	3.54	24.67	16.33

Legend: RCM = graduates/enrolled students; GCA = total spending/enrolled students; ITD = number of teachers per qualification level multiplied by respective weight/total number of teachers; RPA = enrolled students/number of full-time teachers.

Source: elaborated by the authors.

Concerning 2012, the variables "Current spending per enrolled student" (input) and "Relation graduates per enrolled student" (output) stood out to achieve efficiency. In the institutes allocated above the third quartile, the variable "Current spending per enrolled student" showed a lower average when compared to institutes in the first quartile. This may indicate that, for the institution to have been considered efficient in 2012, it should not necessarily have spent more per student. Analyses in further periods would be important to obtain further evidence.

Proceeding with the analysis of the efficient institutes, the mean number of graduates was another factor with a high coefficient when compared to institutes that obtained efficiency scores in the first quartile. Hence, the higher the number of graduating, the better the efficiency will be.

The variable "Degree index of teaching staff" may indicate that the quality of the teaching staff is not necessarily linked to larger numbers of graduates at the units. However, this measure should be analyzed with caution, as other factors should be considered, including the courses that are being offered and the demands from the different regions. As to the variable "Relation number of students per teacher", there were no significant differences between efficient and non-efficient institutes.

As for 2013, it should be observed that, when compared to 2012, the mean spending per student increased. The variable "Current spending per enrolled student" still stands out when the achievement of the degree of those considered efficient is analyzed (superior to third quartile). The variable "Degree index of teaching staff" indicates that the federal institutes are increasing the qualification level of their teachers. This growth may have been motivated by better riteria to hire the teaching staff, as highlighted in the research by Oliveira (2013) among the Ifes.

The mean coefficient for Relation graduate per enrolled student still stands out, similar to 2012. In other words, the higher the number of graduates, the better the institutes' efficiency score.

To further contribute to the previous findings, in Table 7, the test of difference of means was applied to the efficiency scores located in the first quartile and superior to the third quartile, in order to verify whether the measures are statistically different. Thus, it is expected that it will be confirmed whether the financial resources are influending the efficiency of the federal institutions and complying with one of the specific objectives in this research.

Table 7
Test of difference of means of costs per students

Year	Position measure	Statistics	Current spending per enrolled student
2012	1st quartile (*n* = 5)	Mean	9,139.01
		Deviation	1,396.89
	3rd quartile (*n* = 5)	Mean	7,068.40
		Deviation	1,444.39
2013	1st quartile (*n* = 5)	Mean	10,113.72
		Deviation	2,378.61
	3rd quartile (*n* = 5)	Mean	9,626.30
		Deviation	2,825.54
Statistical difference of means		T-test	- 1.1737
		P-value	0.000

Source: elaborated by the authors.

According to the result, there is evidence that there is no significant difference in the means of the quartiles. Thus, it is believed that the spending on the students is not influencing the efficiency of professional and technological education. It should be observed that the institutes that are considered efficient (super to the third quartile) obtained a lower mean cost in 2012 and 2013 when compared to the mean cost of non-efficient institutes (1st quartile). The *t*-test was employed because the sample showed normality and the variance of the sample was available.

The information appoints findings that go against Diniz (2012) with regard to primary education in Brazilian cities, in which the inefficient institutes showed a lower mean cost per student. It is important to mention that, as appointed by Hanushek (1989), studying the resources invested in education is relevant to verify the efficiency of the students' results.

4.3 Influence of growth of Federal Network and retention on efficiency

First, the presence of correlation among the variables in the Tobit model. No scores higher than 80% were found, which would entail further collinearity problems (Gujarati, 2006, p. 289). Only the variable RIV, in 2012 and 2013, revealed negative statistical significance of the IFE measures, ranging around 66.9% and 72.5%, respectively.

Pursuing with the analysis of the variables, the Tobit model for 2012 and 2013 was developed departing from care for the normality of the sample and the heteroscedasticity problem. Table 8 presents the results found.

Table 8
Results for Tobit

Year	2012		2013	
Variables	Coefficient	Standard errors	Coefficient	Standard errors
RIV+	0.259956	0.2068906	0.3561204	0.2820654
IFE-	0.0012734	0.3093422	0.2788749*	0.1506724
Constant	1.137255***	0.3093422	1.588666 ***	0.4550095
Institutes-year	19		19	
Adjusted R^2	0.243		0.3615	
Jarque-Bera test	0.4124 ***		0.5275 ***	

Obs: *, **, *** statistically significant at 10%, 5% and 1%, respectively.
Legend: RIV = (number of new students/number of enrolled students) x 100 ; IFE = (number of retained students/ number of enrolled students) x 100.

Source: elaborated by the authors.

In 2012, the variables were not statistically significant in the efficiency scores when the the mix of inputs "Current spending per enrolled student", "Degree index of teaching staff" and "Relation teacher per enrolled student". Thus, it cannot be concluded that the expansion and retention rates of the students influenced the efficiency of the federal institutes in 2012. In 2013, on the other hand, the variable "Academic efficiency index" is highlighted, with statistical significance (0.2788749) at 10% significance. Nevertheless, the expected signal was not achieved. The reason for that finding may be related to the occurrence of strikes that influence the school calendar, and, consequently, the indices displayed in the accountability report. In other words, if there had been a strike in 2013, the results of students enrolled in 2013, for example, would only be calculated in the subsequent period when the financial year is closed off.

The Tobit model for 2012 and 2013 was estimated as robust to heteroscedasticity, highlighting an R^2 of 0.243 and 0.3615, respectively. Besides this caution with heteroscedasticity, the normality of the residues, when the Jarque-Bera test is applied, the result was statistically significant. Thus, the sample demonstrated normality for both years.

5. Final Considerations

This study aimed to verify the technical efficiency of the Federal Institutes of Education, Science and Technology, the relation of the costs, indicating expansion and retention in the efficiency scores. The analysis of the results showed that only six Federal Institutes, within a sample of 19 units, reached the efficiency score in 2012 and 2013. In general, the isntitutes that are considered efficient showed better mean results per enrolled students and lower current spending per enrolled students, indicating that the achievement of the result is not conditionined to further spending.

To validate this perspective, tests of means were applied in the first quartile with 25% of the institutes with lower efficiency scores, that is, non-efficient: and the 25% of the institutes with scores superior to the third quartile, that is, the efficient units. The findings go against the observations of Diniz (2012), when he considers that lower costs per primary education student are related to inefficient schools. This can be explained by the fact that the government policy in those years was focused on the expansion of professional and technological education. It should be reminded that, according to Law 11.892, from December 9th 2008, 50% of the places at each Federal Institute should serve to attend to the demands for secondary-level technical professional education. This can also be one of the explanations for the result found, as it is linked to education, not only for young people, but also for adults.

About the expansion, when the impact of "Relation candidate per place" and "Relation new student on enrolled students" about the efficiency scores, no further evidence was found for the findings.

As to the research limitations, it should be observed that the institutes present little information that can contribute to the efficiency analysis of the Federal Institutes. Characteristics about the teachers, information about the family aspects are highlighted as necessary to understand the students' performance, considering that, according to Hanushek and Luque (2003), they influence the results measured through the students' learning. Socioeconomic aspects like the family income and the education level of the family heads are also reflected in the research on education and its characteristics (Castro & Vaz, 2007). The Coleman report, issued in 1966, which besides the family aspects identified the individual characteristics and the location where the individual is present, influences the students' level of performance.

It is important to highlight that, according to Cordero, Pedraja and Salinas (2008), there exists no model to measure the technical efficiency that is better than others, but what can be found as an available sample according to the research objective.

The change in relation to the computer system for data collection is another factor that influenced the elaboration of the research, as the data collection for the years before 2012 was negatively affected.

This research stands out because of its focus on Federal Isntitutions, which had nto beenincluded in research on technical efficiency. It contributes to the analysis of the expansion of the Federal Network of EPCT and can be used by the entities responsible for analyzing public resources management and the targets to be achieved which are established in the public policies.

As a suggestion for future studies, besides the creation of indices that sustain the lack of information highlighted in this study, the creation of an index is suggested to measure the accountability, with a view to the proper visualization of the TCU practice in overseeing the accounts of the Federal Institutes and the practice of the efficiency, efficacy and economy concepts.

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