desenvolvimento em QUESTÃO

EFFICIENCY IN BRAZILIAN FEDERAL UNIVERSITIES
A Study With Data Envelopment Analysis (DEA)

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ABSTRACT

This paper aimed to analyze the level of technical efficiency of Brazilian federal universities, from 2012 to 2018, using the Data Envelopment Analysis (DEA) method, with an output-oriented DEA BCC model. Four management indicators instituted by TCU were used as inputs and two quality indicators, as outputs. For that, a sample of 56 federal universities was used. Considering the standard efficiency scores, the results indicated high levels of technical efficiency during the years under analysis. The average technical efficiency of federal universities was 93.7% in 2012, with 17 efficient universities, and 94.5% in 2018, with 18 efficient universities. The years 2015 and 2016 stood out, with 28 and 27 efficient universities respectively, whose national averages were 96.1%. However, due to the benevolence of the BCC model with very small or very large units, some universities may have been considered efficient by default. From 2012 to 2018, the Malmquist Index indicated an increase in the productivity of universities by 2.2%, which occurred in a greater proportion due to the catch-up effect (1.8%) and in a lower proportion by the frontier shift effect (0.4%). In addition, the increase of 1.8% in relative efficiency occurred in a greater proportion due to the increase in pure technical efficiency (1.1%) and in a lower proportion due to the increase in scale efficiency (0.7%). Yet, despite the increase in productivity, there is still room to achieve better quality results and to improvements in the management of resources, in order to reduce waste.

Keywords: data envelopment analysis; technical efficiency; Productivity; federal universities.

EFICIÊNCIA NAS UNIVERSIDADES FEDERAIS BRASILEIRAS – UM ESTUDO POR MEIO DA ANÁLISE ENVOLTÓRIA DE DADOS (DEA)

RESUMO

Este artigo objetivou analisar o nível de eficiência técnica das universidades federais brasileiras, entre 2012 e 2018 por meio da Análise Envoltória de Dados (DEA), com um modelo DEA-BCC orientado a *output*. Foram utilizados como *inputs* quatro indicadores de gestão instituídos pelo TCU, e como *outputs* dois indicadores de qualidade. Para tanto, utilizou-se uma amostra de 56 universidades federais. Considerando a fronteira de eficiência padrão, os resultados indicaram elevados níveis de eficiência técnica durante os anos sob análise. A média de eficiência técnica das universidades federais foi de 93.7% em 2012, com 17 universidades eficientes, e de 94.5% em 2018, com 18 universidades eficientes. Destacaram-se os anos de 2015 e 2016 (com 28 e 27 universidades eficientes respectivamente), cujas médias nacionais foram de 96.1%. Devido, contudo, à benevolência do modelo BCC com unidades muito pequenas ou muito grandes, algumas universidades podem ter sido eficientes por *default*. De 2012 a 2018 verificou-se, por meio do Índice de Malmquist, um aumento na produtividade total das universidades em 2.2%, o qual se deu em maior proporção pelo efeito de emparelhamento (1.8%) e em menor proporção pelo deslocamento da fronteira (0.4%). Ademais, o aumento de eficiência relativa em 1.8% ocorreu em maior proporção pelo aumento de eficiência técnica pura (1.1%) e em menor proporção pelo aumento de eficiência de escala (0.7%). Apesar, entretanto, do aumento na produtividade, ainda há espaço para se alcançar melhores resultados de qualidade e para melhorias no gerenciamento dos recursos, de modo a se reduzir os desperdícios.

Palavras-chave: análise envoltória de dados; eficiência técnica; produtividade; universidades federais.

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INTRODUCTION

In 2018, federal universities in Brazil consumed approximately 32 billion reais. So much investment by taxpayers presupposes that the resources are applied efficiently and that they bring the best possible results. In this sense, comparing applied resources and achieved results among Federal Higher Education Institutions (Ifes) is a fundamental work.

In the literature, it is clear that investment in education is a strategic factor for the development of a country. However, it is worth noting that the increase in investment does not necessarily imply an increase in quality of education, and it is essential to consider efficiency and productivity in resource management (ROSANO-PEÑA; ALBUQUERQUE; MÁRCIO, 2012; PARENTE *et al*., 2021).

Thus, in the search for a more efficient and effective public management model, with a focus on results, the Federal Court of Accounts (TCU), together with the Ministry of Education (MEC), instituted, in 2002, nine management indicators for the IFES, as support tools for institutional evaluation (BARBOSA; FREIRE; CRISÓSTOMO, 2011; SOARES; BORDIN; ROSA, 2019).

In addition, in 2004 the National Higher Education Assessment System (SINAES) established the assessment dimensions of Higher Education Institutions (IES) and, articulated with some public bodies, such as the Brazilian Federal Agency for Support and Evaluation of Graduate Education (CAPES) and the TCU, has sought to improve the management tools of these institutions in search of efficiency and quality (BRASIL, 2004; SOARES; BORDIN; ROSA, 2019).

Therefore, given the importance of evaluating the efficiency of federal universities to obtain better indicators of quality and performance, and better allocation of resources, the main objective of this research was to analyze the level of technical efficiency of Brazilian federal universities, from 2012 to 2018, using the Data Envelopment Analysis (DEA) method.

To achieve the main objective, three specific objectives were defined: to identify the level of technical efficiency of the universities by year and by geographic region, in order to compose comparative rankings of technical efficiency of Brazilian federal universities, to identify the benchmarks for inefficient universities and the projections up to the efficiency frontier, and to verify possible changes in productivity of the universities over the period under analysis.

It is expected with this research, in addition to contributing to the literature on the evaluation of the efficiency of IES, to assist public managers in the search for better management practices of public resources, in order to achieve better quality results and more efficient universities.

The research was divided into six sections, including this introduction. In section two, the theoretical framework on investment in education and efficiency was briefly presented. In section three, the methodology used to achieve the objectives was described. In sections fours and five, the analysis of the results and the discussion were presented, and finally, in section six, the conclusion was presented.

THEORETICAL FRAMEWORK

Investment in education is a strategic factor for the development of a country. According to Costa (2010), the study on the levels of investment in education was driven by the work The Economic Value of Education, published by Schultz in 1963, which gave rise to the Economic

Theory of Education, relating investment in education to the formation of human capital and to the economic and social development of nations. Since then, several other studies have started to address the theme.

In Brazil, public spending on education has been increasing significantly. Based on the management reports of the federal universities, in nominal terms, the current cost[4] of these institutions was around 18 billion reais in 2012, reaching 32 billion reais in 2018. In real terms, deflating this value to January 2012, based on the Broad Consumer Price Index – IPCA, the current cost in 2018 was around 22 billion reais, indicating a real increase of 22.22% in expenditure from 2012 to 2018. According to OECD (2020), in 2017 public spending on education in Brazil represented 5.1% of the Gross Domestic Product (GDP), a percentage above the average of OECD countries, which represented 4.1%.

However, high levels of investment do not necessarily imply improvements in the quality of education. Studies in this perspective emerged from the Coleman Report, 1966, with the proposition that, in the educational context, despite being directly related, the contribution of financial resources explains only small variations in educational performance, which seems to be more associated with the way how these resources are spent. Therefore, the theme on efficiency and productivity improvements in the management of public resources destined for education gains relevance, especially in a context of economic crisis and inevitability of contingency of available resources (ROSANO-PEÑA; ALBUQUERQUE; MÁRCIO, 2012; PARENTE *et al*., 2021).

The concept of productivity refers to the relation between outputs and inputs; it has to do with the ratio between what was produced and the number of resources used to produce. Efficiency, in turn, is a relative concept; it is related to the comparison between production units: what has been produced is compared, given the available resources, with what could have been produced with the same resources (MELLO *et al*., 2005).

Farrell (1957) was a pioneer in the studies on measuring productivity efficiency, which were rediscovered later by Charnes, Cooper and Rhodes (1978). According to Belloni (2000), Charnes, Cooper and Rhodes, based on Farrell's studies, developed a technique for constructing production frontiers and production efficiency indicators known as Data Envelopment Analysis – DEA, which is a non-parametric technique that operates with multiple resources and results, aiming to measure the efficiency of homogeneous production units.

According to Costa (2010), the DEA method has been consolidated as a technique used to estimate the efficiency of the educational sector. Among the main reasons, there is the fact that the educational sector is composed of multiple inputs and multiple products, which facilitates the estimation of the efficiency frontier; besides, it is not necessary, a priori, to specify a function between inputs and outputs, which avoids possible errors resulting from poor specification of the model. In this context, it is worth highlighting some of the Brazilian studies that sought to measure the efficiency and productivity of federal universities.

The research of Belloni (2000) was one of the pioneers that sought to evaluate the efficiency of federal universities in Brazil. The technical efficiency of Brazilian federal universi-

[4] Current Cost without considering expenses with University Hospitals.

ties was evaluated through the DEA-BCC technique and the productive efficiency, through the DEA-CCR technique. Thus, it was possible to classify the universities into four groups: institutions with (I) productive efficiency, (II) technical efficiency and scale inefficiency, (III) technical inefficiency and scale efficiency, and (IV) technical inefficiency and scale inefficiency. Of the 33 federal universities evaluated, six were considered technically efficient (FUFV, UFPA, UFMG, FUOP and UnB), of which five had scale inefficiency and only one (FUFV) had productive efficiency. It was also verified that constant returns to scale are not appropriate for federal universities, given their different sizes; furthermore, it was pointed that the greatest possibilities for productivity growth are in changes in the academic projects of most of these institutions, towards a greater emphasis on research activities.

Subsequently, Oliveira and Turrioni (2006) evaluated the relative efficiency of federal universities using the indicators developed by the TCU (BRASIL, 2006) as outputs and inputs. It was used the DEA-CCR model, which takes into account constant returns to scale. As a result, out of the 19 institutions evaluated, only five were considered inefficient. Comparing this result to Belloni's (2000) work, the research of Oliveira and Turrioni (2006) points in the opposite direction, since most universities were considered efficient.

Costa *et al.* (2012) and Costa *et al.* (2015) measured the efficiency of federal universities, between 2004 and 2008, using the DEA-SBM model with an output orientation. Some of the indicators developed by TCU (BRASIL, 2006) were used as outputs and inputs. Universities were divided into two groups, according to the similarities of their teaching, research and extension activities: group A, containing 28 institutions, and group B, containing 21. The results showed high levels of technical efficiency in all the years evaluated; however, through the Malmquist Index, it was found that there was a decrease in productivity for most universities over the period under analysis.

Nuintin (2014) analyzed the level of relative efficiency of federal universities, from a quantitative and qualitative perspective, using the DEA-BCC model oriented to output. For the qualitative perspective, the Current Cost (CC) was used as input, and the Undergraduate Success Rate (TSG), the General Course Index (IGC), the University Ranking of *Folha* (RUF) and the QS World University Ranking were used as outputs. For this perspective, the average efficiency was 87% in 2010, changing to 88% in 2011. There was also an increase in the productivity of universities from 2010 to 2011, which occurred in a greater proportion due to the frontier shift effect, and in a lesser proportion by the catch-up effect.

Martínez Cohen, Paixão and Oliveira (2018) sought to measure the efficiency of 56 Brazilian federal universities using as variables some of the indicators developed by the TCU (BRASIL, 2006), referring to the year 2016. For data analysis, the universities were divided into two groups (I and II). It was used the DEA-SBM model. Different levels of efficiency were pointed out for each analyzed group. In group I, 37.5% of the universities were considered efficient and in group II, 53.12%. The causes of inefficiency in each group were related to different factors. In group I, the universities with the best Faculty Qualification Index (IQCD) and CAPES concept showed excess in the Current Cost (CC) per student. On the other hand, in group II, the main cause of inefficiency was due to the scarcity of the Graduation Success Rate (TSG) and the excess in the IQCD.

Finally, Rolim *et al.* (2020) evaluated the technical efficiency of federal universities, based on data from 2015, using the DEA-BCC model oriented to output. Current Cost (CC), the number of professors in activity, and the number of employees were used as inputs, and the number of students enrolled and the General Course Index (IGC) were used as outputs. The results indicated an average technical efficiency of 79.2% for the country as a whole. The Southeast, Northeast and North regions were the ones that contained, in this order, the largest number of efficient universities, which showed that there was no concentration of efficient universities in the most developed regions in the country. In addition, in order to increase the rationality of resources, it would be necessary, in addition to increasing educational results, to reduce the costs, the number of professors and, in particular, the number of employees.

METHODOLOGY

To analyze the level of technical efficiency of Brazilian federal universities, it was used the Data Envelopment Analysis (DEA) method. DEA is a tool based on mathematical programming models whose function is to measure the efficiency of Decision-Making Units (DMUs). It is a non-parametric approach that uses linear programming techniques to determine which DMUs are efficient, in order to project the path of inefficient DMUs to the efficiency frontier (MELLO *et al*., 2005; TAVARES; MEZA, 2015).

The determination of relative efficiency occurs through the comparison of a set of DMUs that use the same inputs to generate the same results (outputs), which are distinguished only by the quantities of inputs used and outputs generated. When defining the units with the best practices through the weighted ratio between outputs and inputs, an efficient empirical production frontier is built, on which the efficient units are located (with an efficiency score equivalent to 1 or 100%). Inefficient units, in turn, are located below this frontier. In addition, the DEA method also determines where inefficiencies arise and indicates the benchmarks for inefficient units (MELLO *et al*., 2005; LOBO *et al*., 2009).

As for orientation, the DEA model can be divided into input-oriented, which seeks to minimize the resources used, maintaining at least the levels of results obtained, and output-oriented, which aims to maximize the results obtained, given the resources available. As for the mathematical models used, the classic DEA models are classified in CCR and BCC. The CCR model developed by Charnes, Cooper and Rhodes, in 1978, assumes constant returns to scale, which means that the inputs and outputs are proportional to each other; thus, the total efficiency is calculated by comparing a unit with all its competitors. On the other hand, the BCC model, developed by Banker, Charnes and Cooper, in 1984, assumes variable returns to scale, allowing the division of total efficiency into technical and scale efficiency; thus, in the calculation of technical efficiency, only units operating on similar scales are compared (MELLO *et al*., 2005; MARIANO; ALMEIDA; REBELATTO, 2006; JI; LEE, 2010).

Among the advantages of using the DEA method, we highlight the ease of application of the method and the formulation of few hypotheses. Besides, as it is a non-parametric technique, it does not require the use of explicit functions that relate inputs to outputs. The method seeks to optimize each individual observation with the objective of estimating an efficiency frontier, determined by the Pareto-efficient units. Multiple inputs and outputs can be used simultaneously without any assumptions about the distribution of the data. However, caution is needed, since, although it allows the inclusion of variables indiscriminately, the greater the number of inputs and outputs, the lower the discriminating power of the relative efficiency analysis (DYSON *et al*., 2001; MELLO *et al*., 2005; JI; LEE, 2010).

Definition and Selection of DMUs

The application of DEA requires that the set of DMUs selected uses the same inputs and generates the same results, varying only in intensity. The set must be homogeneous, that is, it must perform the same tasks, have the same objectives, operate under the same market conditions and be autonomous in decision-making (DYSON *et al*., 2001; MELLO *et al*., 2005).

In that regard, the set of Brazilian federal universities was selected as DMUs, which are governed by the same legislation and maintained, mainly, with Union resources. In 2018, there were 68 federal universities in operation. Those that had complete data on the management and quality indicators from 2012 to 2018 were kept in the sample. Therefore, 12 universities were excluded (UFFS, Unilab, Unila, UFSB, Ufca, Ufob, Unifesspa, UFCat, UFJ, UFR, Ufape and UFDPar) and 56 institutions remained in the sample, which represented 82.35% of the universe of federal universities existing in 2018.

Selection of Variables

The selection of outputs and inputs must be made from a set of possible variables, so that there is greater knowledge about the units to be evaluated (MELLO *et al*., 2005). Furthermore, it is important to analyze whether there is a positive correlation between the input and output variables of the model (DYSON *et al*., 2001).

Thus, as a starting point, 12 management indicators used to assess the performance of federal universities were previously considered as inputs, and as outputs, two indicators that express the quality results of these institutions were considered. Subsequently, taking into account the correlations between inputs and outputs (APPENDIX A), as well as other studies carried out in the Brazilian context (OLIVEIRA; TURRIONI, 2006; COSTA *et al*., 2012; NUINTIN, 2014; COSTA *et al*., 2015; MARTÍNEZ COHEN; PAIXÃO; OLIVEIRA, 2018; ROLIM *et al*., 2020), four input variables and two output variables were selected for the model, in order to achieve a reasonable level of discrimination, since it is recommended that the number of DMUs should be at least equal to twice the product between inputs and outputs, according to Dyson *et al*. (2001).

The first input (Current Cost – CC) is related to the maintenance cost of federal universities, including expenses with professors and employees in activity, and other expenses, such as electricity, water, warehousing and cleaning materials, student assistance and outsourcing services (BRASIL, 2006; ROLIM *et al*., 2020). However, for this research, the costs related to hospital complexes were disregarded, since not all federal universities have university hospitals. The second input is the Number of Equivalent Professors (NPE), which considers even substitute and visiting professors (excluding those on leave and assigned to other institutions). When calculating the indicator, professors who work full-time or 40 hours/week are assigned a weight of 1.00; to those who work 20 hours/week, weight 0.50 (BRASIL, 2006).

The third input is the Number of Equivalent Employees (NFE), which considers civil servants and outsourced employees, whose function is to offer administration and support services to teaching and research activities. When calculating the indicator, those who work 40 hours/week are assigned a weight of 1.00; to those who work 30 hours/week, weight 0.75; and to those who work 20 hours/week, weight 0.50 (BRASIL, 2006; ROLIM *et al*., 2020). Finally, the fourth input (Faculty Qualification Index – IQCD) refers to the weighted average of faculty qualification, obtained through the following weights: 5 for Doctoral Degree/PhD, 3 for Master's Degree, 2 for *Lato Sensu* Postgraduate Degree, and 1 for Undergraduate Degree (BRASIL, 2006).

As for the outputs, the first one selected was the General Course Index (IGC), which is an official indicator of the Brazilian Ministry of Education that seeks to express the quality of Undergraduate, Master's and Doctoral courses (BITTENCOURT; CASARTELLI; MORAIS, 2009). It considers annually the weighted average of Preliminary Course Concepts (CPC) grades for the undergraduate courses and CAPES grades for the Master's and Doctoral courses. The weighting is done through the enrollment of students at their respective levels of education (INEP, 2016). The IGC result is a continuous variable in the range between 0 and 5; the closer to 5, the better for the institution.

Finally, the second output (University Ranking of *Folha* – RUF) is an independent quality indicator, which is considered, in Brazil, one of the most consolidated quality indicators in the academic field. The RUF classifies Brazilian universities annually based on 5 indicators: scientific research (42%), quality of education (32%), labor market (18%), internationalization (4%) and innovation (4%). Its result ranges from 0 to 100; the closer to 100, the better for the institution (RUF, 2019).

The data referring to the input variables were collected from the Integrated Monitoring, Execution and Control System of the Ministry of Education (SIMEC/MEC) and from the Management Reports of the federal universities. The data referring to the IGC and RUF indicators were collected, respectively, from the National Institute for Educational Studies and Research *Anísio Teixeira* (INEP) database and from the University Ranking of *Folha de São Paulo* website.

Selection and Application of the Model

Given the fixed disposition, by legal force, of the financial and human resources used as inputs in the model, as well as the fact that these inputs capture the different sizes of Brazilian federal universities, it was used in this research the DEA BCC model, proposed by Banker, Charnes and Cooper (1984), with an output orientation, so that universities are compared only with those that operate on similar scales and that they seek to maximize their quality results, with the available resources. The equations (1) and (2) express the output-oriented DEA BCC model in the form of Multipliers and Envelope, respectively:

$$\begin{aligned}
&\boldsymbol{Min\ h_0} = \textstyle\sum_{i=1}^{r} v_i x_{io} + v_{*} \\
&\textit{subject to:} \\
&\textstyle\sum_{j=1}^{s} u_j y_{jo} = 1 \\
&\textstyle\sum_{j=1}^{s} u_j y_{jk} - \sum_{i=1}^{r} v_i x_{ik} + v_{*} \le 0, \forall k \\
&v_i, u_j \ge 0, v_{*} \in \mathcal{R}
\end{aligned} \tag{1}$$

$$\begin{aligned}
&\boldsymbol{Max\ h_0} \\
&\textit{subject to:} \\
&x_{jo} - \textstyle\sum_{k=1}^{n} x_{ik} \lambda_k \ge 0, \forall i \\
&-h_0 y_{jo} + \textstyle\sum_{k=1}^{n} y_{jk} \lambda_k \ge 0, \forall j \\
&\textstyle\sum_{k=1}^{n} \lambda_k = 1 \\
&\lambda_k \ge 0, \forall k
\end{aligned} \tag{2}$$

Each DMU k, $k = 1...n$ is a production unit that uses r inputs, x_{ik}, $i = 1...r$, to produce s outputs, y_{jk}, $j = 1...s$. In both equations, h_o is the efficiency of the DMU under analysis; x_{io} and y_{jo} are, in this order, the inputs and outputs of the DMU. In (1), v_i and u_j are the weights calculated by the model for inputs and outputs respectively; in (2), $\sum_{k=1}^{n} \lambda_k = 1$ represents the scale factor and λ_k represents the contribution of the DMU k in formulating the target of the DMU o (MELLO *et al*., 2005).

Malmquist Index

To measure the productivity change of federal universities, it was used the Malmquist-DEA method, with panel data for the comparison of two periods of time. The use of the Malmquist Index (MI) is justified, given that different researchers, such as Nuintin (2014) and Costa *et al*. (2015), have chosen to use it to analyze the productivity gains of DMUs due to its advantage of allowing the comparison of DMUs (in two different years) under different technology, reducing biased comparisons.

According to equation (3), Färe *et al*. (1994) specified the output-oriented Malmquist Index (MI):

$$\boldsymbol{MI} = \left[\left(\frac{D_O^t(x^{t+1},y^{t+1})}{D_O^t(x^t,y^t)}\right)\left(\frac{D_O^{t+1}(x^{t+1},y^{t+1})}{D_O^{t+1}(x^t,y^t)}\right)\right]^{\frac{1}{2}} \qquad \textbf{(3)}$$

$D_O^t(x^t, y^t)$ represents the efficiency of DMU *o* in the period *t; $D_O^{t+1}(x^{t+1}, y^{t+1})$*, the efficiency of DMU *o* in the period *t+1*; $D_O^t(x^{t+1}, y^{t+1})$, the constraints in the period *t*, with data from DMU *o* in the period *t+1;* and $D_O^{t+1}(x^t, y^t)$, the constraints in the period *t+1*, with data from DMU *o* in the period *t* (FÄRE *et al*., 1994; LOBO *et al*., 2009). The MI can be decomposed into the components of Relative Efficiency Changes (EFFCH), in order to verify the catch-up effect, and of Technological Changes (TECHCH), in order to verify the frontier shift effect.

Additionally, it is also possible to decompose the EFFCH component, in order to verify the changes in Pure Technical Efficiency (PECH), under variable returns to scale, and the changes in Scale Efficiency (SECH). The MI can assume three distinct values: MI> 1 indicates that there was an increase in productivity from one period to the next; MI <1 indicates that there was an involution in productivity from one period to the next; and MI = 1 indicates constant productivity from one period to the next. For the components EFFCH, TECHCH, PECH and SECH, it is applied the same interpretation (FÄRE *et al*., 1994; COELLI *et al*., 2005).

RESULTS

Table 1 shows the descriptive statistics (D.S) of the inputs and outputs selected for the 56 universities under analysis, between 2012 and 2018. It presents the values of means, standard deviation, minimums and maximums.

The Current Cost (CC) of the universities, in nominal terms, had the lowest average value in 2012 (327.72 million reais), reaching the highest in 2018 (577.62 million reais). Taking into account the maximum and minimum values, UFRJ was the institution with the highest expenditure, approaching the range of 1.02 billion reais in 2012, and 2.14 billion reais in 2018.

The institutions with the lowest expenditure were Unifap (62.28 million reais) in 2012, UFCSPA (72.30 million reais to 84.35 million reais) between 2013 and 2014, and Ufopa (28,80 million reais to 38.32 million reais) between 2015 and 2018. The Number of Equivalent Professors (NPE) varied on average from 1242.07 to 1504.18; UFRJ was the institution with the highest NPE, with a range from 3890.00 to 4610.00. On the other hand, UFCSPA was the institution with the lowest NPE in 2012 (259.00), and between 2014 and 2018 (with a variation from 314.00 to 360.50); Ufra was the institution with the lowest NPE in 2013 (254.00).

Table 1 – Descriptive Statistics (D.S) of Inputs and Outputs of Federal Universities from 2012 to 2018

Indicator	D.S	2012	2013	2014	2015	2016	2017	2018
CC* (Input)	**Mean**	327.72	403.88	445.08	473.26	519.90	558.91	577.62
	Std. Deviation	243.10	305.67	329.31	333.53	358.86	380.34	388.17
	Minimum	62.28	72.30	84.35	28.80	33.99	35.45	38.32
	Maximum	1015.70	1456.78	1695.27	1829.52	2009.63	2166.05	2137.19
NPE (Input)	**Mean**	1242.07	1304.86	1348.29	1404.34	1447.52	1470.13	1504.18
	Std. Deviation	807.98	806.83	850.25	886.54	873.62	873.14	894.95
	Minimum	259.00	254.00	314.00	322.00	322.00	341.50	360.50
	Maximum	3890.00	3932.00	4409.00	4409.00	4517.00	4485.00	4610.00
NFE (Input)	**Mean**	1840.65	2080.11	2131.25	2135.07	2144.55	2058.86	2058.98
	Std. Deviation	1473.97	1767.78	1715.03	1715.46	1649.73	1530.12	1476.70
	Minimum	285.80	292.05	310.55	336.55	348.05	354.80	373.30
	Maximum	8491.00	10781.00	10593.00	10813.00	9819.00	8165.00	7855.00
IQCD (Input)	**Mean**	4.09	4.16	4.21	4.25	4.31	4.35	4.41
	Std. Deviation	0.38	0.39	0.39	0.37	0.39	0.35	0.33
	Minimum	3.16	3.18	3.28	3.36	3.38	3.43	3.58
	Maximum	5.00	5.00	5.00	5.00	5.24	5.00	5.11
IGC (Output)	**Mean**	3.38	3.38	3.38	3.39	3.42	3.47	3.48
	Std. Deviation	0.48	0.49	0.51	0.49	0.45	0.43	0.41
	Minimum	2.03	1.93	2.14	2.34	2.46	2.55	2.60
	Maximum	4.28	4.29	4.35	4.29	4.30	4.31	4.30
RUF (Output)	**Mean**	51.03	63.62	65.94	65.27	67.66	67.78	68.44
	Std. Deviation	18.76	20.66	20.76	20.57	19.67	19.76	18.36
	Minimum	4.36	15.41	15.80	18.55	24.64	23.64	27.51
	Maximum	91.76	95.64	96.55	96.74	97.46	97.42	97.29

Note: * Values of Current Cost (CC) in millions of reais.

Source: Research Data.

The Number of Equivalent Employees (NFE) varied on average from 1840.65 to 2058.98; UFRJ was the institution with the highest NFE in the entire period, with a range from 8491.00 to 7855.00. On the other hand, UFCSPA was the institution with the lowest NPE in the entire period, with a range from 285.80 to 373.30. The Faculty Qualification Index (IQCD) ranged from 4.09 to 4.41 on average. The institutions with the best scores were UFAC between 2012 and 2015 and in 2017 (score 5 in those years), and UFRRJ in 2016 and 2018 (5.24 and 5.11 respectively). The institutions with the worst scores were Ufam in 2012 (3.16), Ufac in 2013 (3.18), Unifap between 2014 and 2016 (3.28 to 3.38) and 2018 (3.58), and UFRR in 2017 (3.43).

As for the General Course Index (IGC), the lowest national average was 3.38 between 2012 and 2014, and the highest was 3.48 in 2018. UFRGS was the institution with the best scores in the IGC throughout the period, with a range from 4.28 to 4.30. On the other hand, the institutions with the worst scores were Ufopa between 2012 and 2014 (2.03 to 2.14), Ufra in 2015 (2.34), and Unifap between 2016 and 2018 (2.46 to 2.60). Regarding the University Ranking of *Folha* (RUF), national averages were concentrated between 51.03 in 2012 and 68.44 in 2018. UFMG was the first ranked in 2012 (91.76) and in 2014 (96.55), and UFRJ, in turn, was the first ranked in 2013 (95.64) and between 2015 and 2018 (96.74 to 97.29). Ufopa was the worst ranked in 2012 (4.36) and in 2013 (15.41), and Unifap was the worst ranked between 2014 and 2018 (15.80 to 27.51).

Tables 2, 3 and 4 summarize the standard efficiency scores of Brazilian federal universities for each year, between 2012 and 2018, with the rank of each DMU, and how many times has a university been considered a benchmark (BM) for those located below the efficiency frontier.

When analyzing the results, in 2012, 17 universities were located on the efficiency frontier, equivalent to approximately 30% of the sample. Universities on the efficiency frontier are benchmarks for those located below the frontier; thus, Ufam stood out as a benchmark for institutions considered inefficient, being a benchmark for 27 universities. On the other hand, although being considered efficient, UFABC, Ufopa, UFRJ, Unifal and Unifei were not benchmarks for inefficient universities. Besides, of the 39 universities below the efficiency frontier, UFT achieved the lowest score, with an efficiency level of 0.79.

In 2013, there was a change in the efficiency frontier. 25 universities, approximately 45% of the sample, were on the efficiency frontier. UFTM stood out as a benchmark for 16 institutions considered inefficient. In contrast, six efficient universities (UFABC, Ufopa, UFPR, UFRJ, Unifap and Univasf) were not benchmarks for institutions considered inefficient. In relation to 2012, three universities left the efficiency frontier (Ufam, Unifal and Unifei) and 11 went up to it (UFSC, UTFPR, UFRR, UFV, UFMS, UFC, Ufop, UFRN, UFCG, Ufra and Univasf). In addition, of the 31 universities considered inefficient, UFRPE achieved the lowest efficiency score (0.78).

Table 2 – Rankings of Technical Efficiency of Federal Universities (2012-2014)

2012				2013				2014			
Rank	**DMU**	**Score**	**BM**	**Rank**	**DMU**	**Score**	**BM**	**Rank**	**DMU**	**Score**	**BM**
1	UFAM	1.00	27	**1**	UFTM	1.00	16	**1**	UFV	1.00	21
1	UFTM	1.00	26	**1**	UFSC	1.00	14	**1**	UFAM	1.00	14
1	UFSCAR	1.00	24	**1**	UTFPR	1.00	12	**1**	UFLA	1.00	11
1	UFAC	1.00	15	**1**	UFBA	1.00	11	**1**	UFSCAR	1.00	10
1	UFMG	1.00	13	**1**	UFCSPA	1.00	10	**1**	UFBA	1.00	08
1	UFLA	1.00	11	**1**	UFRR	1.00	10	**1**	UFCSPA	1.00	08
1	UFCSPA	1.00	10	**1**	UFAC	1.00	08	**1**	UFERSA	1.00	07
1	UFRGS	1.00	09	**1**	UFLA	1.00	08	**1**	UFTM	1.00	07
1	UNIFAP	1.00	06	**1**	UFV	1.00	07	**1**	UFRN	1.00	06
1	UFPR	1.00	05	**1**	UFMS	1.00	05	**1**	UFC	1.00	05
1	UFBA	1.00	04	**1**	UFSCAR	1.00	05	**1**	UFRGS	1.00	04
1	UNIFESP	1.00	03	**1**	UFC	1.00	04	**1**	UNIVASF	1.00	04
1	UFABC	1.00	-	**1**	UFOP	1.00	04	**1**	UFAC	1.00	03
1	UFOPA	1.00	-	**1**	UFRN	1.00	03	**1**	UFSC	1.00	03
1	UFRJ	1.00	-	**1**	UFMG	1.00	02	**1**	UFMG	1.00	02
1	UNIFAL	1.00	-	**1**	UFRGS	1.00	02	**1**	UNIFAP	1.00	02

1	UNIFEI	1.00	-	**1**	UFCG	1.00	01	**1**	UTFPR	1.00	02
18	UFSC	0.99	-	**1**	UFRA	1.00	01	**1**	UFABC	1.00	01
18	UFV	0.99	-	**1**	UNIFESP	1.00	01	**1**	UFAL	1.00	01
18	UFRN	0.99	-	**1**	UFABC	1.00	-	**1**	UFRJ	1.00	01
22	UFC	0.98	-	**1**	UFOPA	1.00	-	**1**	UNIFAL	1.00	01
23	UFMS	0.97	-	**1**	UFPR	1.00	-	**1**	UNIFESP	1.00	01
23	UFCG	0.97	-	**1**	UFRJ	1.00	-	**1**	UFCG	1.00	-
25	UFRA	0.96	-	**1**	UNIFAP	1.00	-	**1**	UFPR	1.00	-
25	UFOP	0.96	-	**1**	UNIVASF	1.00	-	**1**	UFRA	1.00	-
29	UTFPR	0.95	-	**26**	UFSM	0.99	-	**1**	UFRR	1.00	-
29	UNIVASF	0.95	-	**30**	UNIFEI	0.98	-	**1**	UNIFEI	1.00	-
34	UNB	0.93	-	**32**	UNB	0.97	-	**28**	UFSM	0.99	-
40	UFG	0.91	-	**35**	UFAM	0.96	-	**28**	UFG	0.99	-
49	UFRR	0.84	-	**36**	UFAL	0.95	-	**30**	UNB	0.98	-
51	UFMT	0.83	-	**38**	UNIFAL	0.94	-	**30**	UFPE	0.98	-
51	UFES	0.83	-	**41**	UFERSA	0.91	-	**34**	UFOP	0.95	-
54	UFRPE	0.81	-	**41**	UNIRIO	0.91	-	**32**	UNIRIO	0.97	-
55	UNIPAMPA	0.80	-	**55**	UFMA	0.85	-	**55**	UFRRJ	0.84	-
56	UFT	0.79	-	**56**	UFRPE	0.78	-	**56**	UFOPA	0.75	-

Source: Research Data.

As for 2014, 27 universities, approximately 48% of the sample, were considered efficient. This change in the frontier was due to the fact that Ufam, Ufersa, Ufal, Unifal and Unifei went up to the efficiency frontier, and UFMS, Ufop and Ufopa left the frontier. Regarding benchmark universities, UFV and Ufam stood out, being a reference for 21 and 14 institutions, respectively. UFCG, UFPR, Ufra, UFRR and Unifei, in spite of being considered efficient, were not benchmarks for the universities below the efficiency frontier. In addition, Ufopa had the worst result among the set of inefficient universities, with an efficiency score of 0.75.

Table 3 – Rankings of Technical Efficiency of Federal Universities (2015-2017)

2015				**2016**				**2017**			
Rank	**DMU**	**Score**	**BM**	**Rank**	**DMU**	**Score**	**BM**	**Rank**	**DMU**	**Score**	**BM**
1	UFV	1.00	18	**1**	UFCG	1.00	11	**1**	UFCG	1.00	29
1	UNIFEI	1.00	16	**1**	UFC	1.00	10	**1**	UFCSPA	1.00	20
1	UFC	1.00	13	**1**	UFV	1.00	10	**1**	UFSCAR	1.00	18
1	UNIRIO	1.00	13	**1**	UFERSA	1.00	09	**1**	UFC	1.00	11
1	UFLA	1.00	11	**1**	UFG	1.00	09	**1**	UFOPA	1.00	09
1	UFAL	1.00	07	**1**	UFSCAR	1.00	09	**1**	UNIFEI	1.00	09
1	UFSCAR	1.00	07	**1**	UFSJ	1.00	08	**1**	UFLA	1.00	08
1	UFAM	1.00	05	**1**	UFLA	1.00	07	**1**	UFRGS	1.00	08
1	UFERSA	1.00	05	**1**	UFCSPA	1.00	06	**1**	UFRR	1.00	07
1	UFRR	1.00	04	**1**	UNB	1.00	06	**1**	UFV	1.00	07
1	UFCG	1.00	03	**1**	UNIFEI	1.00	06	**1**	UNB	1.00	05
1	UFMG	1.00	03	**1**	UFABC	1.00	05	**1**	UFAL	1.00	03
1	UFSC	1.00	03	**1**	UFAM	1.00	05	**1**	UFG	1.00	03
1	UFPE	1.00	02	**1**	UFAC	1.00	04	**1**	UFMG	1.00	03
1	UFRGS	1.00	02	**1**	UNIFAP	1.00	04	**1**	UFAM	1.00	02
1	UFRJ	1.00	02	**1**	UFMG	1.00	03	**1**	UFPR	1.00	02
1	UFCSPA	1.00	01	**1**	UFRGS	1.00	03	**1**	UFRJ	1.00	02
1	UFG	1.00	01	**1**	UFRJ	1.00	03	**1**	UNIFESP	1.00	02
1	UFPR	1.00	01	**1**	UFSC	1.00	03	**19**	UFSC	0.99	-
1	UFABC	1.00	-	**1**	UFOPA	1.00	02	**19**	UTFPR	0.99	-

1	UFAC	1.00	-	**1**	UFPR	1.00	02	**19**	UFABC	0.99	-
1	UFOPA	1.00	-	**1**	UFAL	1.00	01	**19**	UFOP	0.99	-
1	UFRA	1.00	-	**1**	UFRN	1.00	01	**19**	UFBA	0.99	-
1	UFRN	1.00	-	**1**	UNIFAL	1.00	01	**19**	UFPEL	0.99	-
1	UNIFAP	1.00	-	**1**	UNIFESP	1.00	01	**25**	UFPE	0.98	-
1	UNIFESP	1.00	-	**1**	UFRR	1.00	-	**26**	UFTM	0.97	-
1	UNIVASF	1.00	-	**1**	UTFPR	1.00	-	**30**	UNIFAL	0.94	-
1	UTFPR	1.00	-	**28**	UNIVASF	0.99	-	**30**	UFERSA	0.94	-
29	UNIFAL	0.99	-	**30**	UFPE	0.98	-	**33**	UFRN	0.93	-
29	UFBA	0.99	-	**30**	UNIRIO	0.98	-	**37**	UFSJ	0.92	-
32	UFTM	0.98	-	**34**	UFSM	0.97	-	**44**	UFAC	0.90	-
35	UNB	0.97	-	**36**	FURG	0.96	-	**49**	UNIFAP	0.88	-
53	UFT	0.85	-	**42**	UFRA	0.94	-	**52**	UFMA	0.86	-

Source: Research Data.

In 2015, 28 universities were considered efficient (50% of the sample). UFV was a benchmark for 18 universities located below the frontier. On the other hand, even located on the efficiency frontier, nine universities (UFABC, Ufac, Ufopa, Ufra, UFRN, Unifap, Unifesp, Univasf and UTFPR) were not benchmarks for inefficient institutions. In reference to 2014, three universities left the frontier (Ufba, UFTM and Unifal) and four went up to the it (Unirio, Ufpe, UFG and Ufopa). Besides, of the 28 universities considered inefficient, UFT, UFSJ, Ufma and UFRPE had the worst result, with an efficiency score of 0.85.

As for 2016, 27 universities, approximately 48% of the sample, were considered efficient, with emphasis on UFCG, which was a benchmark for 11 institutions located below the frontier. However, although located on the efficiency frontier, UFRR and UTFPR were not benchmarks for the institutions considered inefficient. In relation to 2015, four universities left the frontier (Unirio, Ufpe, Ufra and Univasf), and three went up to it (UFSJ, UNB and Unifal). In addition, of the 29 universities considered inefficient, Unir obtained the worst efficiency result (0.80).

Table 4 – Ranking of Technical Efficiency of Federal Universities (2018)

2018											
Rank	**DMU**	**Score**	**BM**	**Rank**	**DMU**	**Score**	**BM**	**Rank**	**DMU**	**Score**	**BM**
1	UFLA	1.00	26	**19**	UNIVASF	0.99	-	**39**	UFOP	0.92	-
1	UFAM	1.00	13	**21**	UFPE	0.98	-	**39**	UFPA	0.92	-
1	UFCSPA	1.00	13	**21**	UFABC	0.98	-	**41**	UFRA	0.91	-
1	UFC	1.00	12	**21**	UFERSA	0.98	-	**41**	UFF	0.91	-
1	UFSCAR	1.00	11	**21**	UFMT	0.98	-	**41**	UFU	0.91	-
1	UFAC	1.00	09	**25**	UFES	0.97	-	**41**	UNIFAL	0.91	-
1	UFRGS	1.00	09	**25**	UFBA	0.97	-	**45**	UFGD	0.90	-
1	UNB	1.00	09	**27**	UFAL	0.96	-	**46**	UFMA	0.89	-
1	UNIFEI	1.00	08	**27**	UNIR	0.96	-	**47**	UFVJM	0.88	-
1	UFV	1.00	06	**29**	UFTM	0.95	-	**48**	UFS	0.87	-
1	UFPR	1.00	05	**29**	UTFPR	0.95	-	**48**	UFRPE	0.87	-
1	UFCG	1.00	04	**31**	UFG	0.94	-	**48**	UFPB	0.87	-
1	UFRJ	1.00	02	**31**	UFSM	0.94	-	**51**	UFRRJ	0.86	-
1	UFRR	1.00	02	**33**	UFPI	0.93	-	**51**	FURG	0.86	-
1	UNIFAP	1.00	02	**33**	UFRN	0.93	-	**51**	UFT	0.86	-
1	UFOPA	1.00	01	**35**	UFSJ	0.92	-	**51**	UFMS	0.86	-
1	UFMG	1.00	-	**35**	UNIRIO	0.92	-	**55**	UFRB	0.83	-
1	UNIFESP	1.00	-	**35**	UFPEL	0.92	-	**56**	UNIPAMPA	0.78	-
19	UFSC	0.99	-	**35**	UFJF	0.92	-				

Source: Research Data.

In 2017, 18 universities were considered efficient, approximately 32% of the sample. This change in the frontier was due to the fact that nine universities left the frontier (Ufersa, UFSJ, UFABC, Ufac, Unifap, UFSC, UFRN, Unifal and UTFPR). Regarding the benchmark universities, UFCG and UFCSPA stood out, being a reference for 29 and 20 inefficient institutions, in that order. Furthermore, Unipampa obtained the worst result among the set of inefficient universities, with an efficiency score of 0.82.

Finally, in 2018, 18 universities were considered efficient, approximately 32% of the sample. UFLA stood out as a benchmark, being a reference for 26 universities considered inefficient. In contrast, despite being on the frontier, UFMG and Unifesp were not benchmarks for institutions considered inefficient. In reference to 2017, two universities left the efficiency frontier (Ufal and UFG) and two went up to it (Ufac and Unifap). Besides, of the 38 universities considered inefficient, Unipampa maintained the worst result, with an efficiency level of 0.78.

However, it is important to highlight that, according to Dyson *et al*. (2001) and Mello *et al*. (2005), the model of variable returns to scale can be benevolent with some units, which can take advantage of some of the weights of the variables to reach the standard efficiency frontier. Thus, very small or very large units, as well as units with the lowest value for a given input or the highest value for a given output can be considered efficient by default.

In this perspective, UFRJ may have been considered efficient by default due to its size, since it presented the highest values for the inputs CC, NPE and NFE between 2012 and 2018. UFRGS and UFMG may also have benefited from the model, since, besides their large size, they presented, in this order, the best scores for the IGC (2012 – 2018) and for the RUF (2012 and 2014).

In addition, UNIFAP, UFOPA, UFCSPA and UFRA may have been considered efficient by default because they presented the lowest value for one of the inputs over the period. UNIFAP, in addition to its small size, presented the lowest value for the CC in 2012. UFOPA, in turn, presented the lowest value for the CC between 2015 and 2018. As for UFCSPA, in addition to being very small, it presented the lowest value for the CC between 2013 and 2014, as well as the lowest values for the NPE (2012 and between 2014 and 2018) and NFE (2012 – 2018). Finally, UFRA presented the lowest value for the NPE in 2013.

Therefore, once the analysis by year was completed, the analysis of the technical efficiency of the universities by geographic region was carried out, according to table 5, with the average values of technical efficiency, as well as the number of efficient universities by region.

Table 5 – Average Technical Efficiency of Federal Universities by Region (2012 – 2018)

Region	2012	2013	2014	2015	2016	2017	2018
Midwest	0.899 (00)	0.962 (01)	0.942 (00)	0.958 (01)	0.973 (02)	0.942 (02)	0.937 (01)
Northeast	0.932 (01)	0.939 (05)	0.952 (07)	0.952 (07)	0.959 (05)	0.932 (03)	0.934 (02)
North	0.931 (04)	0.952 (05)	0.936 (05)	0.955 (06)	0.943 (05)	0.933 (03)	0.961 (05)
Southeast	0.943 (09)	0.963 (09)	0.963 (10)	0.963 (09)	0.963 (10)	0.959 (07)	0.950 (07)
South	0.958 (03)	0.965 (05)	0.965 (05)	0.975 (05)	0.972 (05)	0.963 (03)	0.937 (03)
National	0.937 (17)	0.955 (25)	0.954 (27)	0.961 (28)	0.961 (27)	0.947 (18)	0.945 (18)

Note: Number of efficient universities in parentheses.

Source: Research Data.

For the country as a whole, the average technical efficiency ranged from 93.7% in 2012 to 94.5% in 2018, with emphasis on 2015 and 2016, when the national average was 96.1%. In 2012, the South and Southeast regions had, respectively, the best efficiency averages (95.8% and 94.3%), while the Midwest region had an average efficiency of 89.9%, below the national average. In 2016, the Midwest region had best efficiency average (93.7%), while the North region started to occupy the worst position, with an average of 94.3%, below the national average. In 2018, the North region started to occupy the best position, with an average efficiency of 96.1%, in contrast to the Northeast region, which went to the worst position, with an average of 93.4%, also below the national average.

Regarding the number of efficient universities, the Southeast region, between 2012 and 2018, was the one that covered the largest number of efficient universities, varying between ten universities, in 2014, and seven, in 2017 and 2018. Then, the North region was the second that most contained efficient universities, with a variation of six institutions, in 2015, to three, in 2017. The third region with more efficient universities was the Northeast region, with seven institutions between 2014 and 2015, and one in 2012. The fourth region with the most efficient universities was the South region, with a variation of five universities, between 2013 and 2016, to three, in 2012 and between 2017 and 2018. Finally, the Midwest region stood out for having the smallest number of efficient universities, with no efficient universities in 2012 and 2014, and two, between 2016 and 2017. Thus, based on this regional distribution, it was clear that there was no concentration of efficient universities in the more developed regions of the country.

After analyzing the efficiency frontiers by year and by region, it was interesting to verify, through the Malmquist Index (MI), the change in productivity of the universities, that is, if there was an improvement or worsening in the relation between their outputs and inputs. For that, it was necessary to consider a panel analysis (Table 6). In addition, for the 2012 – 2018 panel, the MI was broken down into the Relative Efficiency Changes (EFFCH) and Technological Changes (TECHCH) components, and the EFFCH component into the Pure Technical Efficiency Changes (PECH) and Scale Efficiency Changes (SECH) components.

The results for the 2012 – 2013 panel showed that there was an increase in the productivity of the universities by 6.4% (1.064). In this period, the inputs CC, NPE, NFE and IQCD increased, respectively, by 23%, 5%, 13% and 2%, while the scores for the RUF increased by 23% and the scores for the IGC remained unchanged. 44 universities had an increase in productivity and 12 had a decrease. Of the institutions with increased productivity, UFAC obtained the best result, with an increase of 23.3% (1.233). Among the universities with a drop in productivity, UFRA stood out with the worst result, with a decrease of 10.7% (0.893).

Table 6 – Malmquist Index: Change in Productivity of Federal Universities (2012 – 2018)

Panel	MI = 1	MI > 1	MI < 1	MI Average	MI Max.	MI Min.
2012 – 2013	0	44	12	1.064	1.233	0.893
2013 – 2014	0	25	31	0.990	1.180	0.856
2014 – 2015	0	16	40	0.994	1.975	0.854
2015 – 2016	3	21	32	0.997	1.275	0.863
2016 – 2017	2	21	33	0.992	1.123	0.887
2017 – 2018	0	12	44	0.986	1.072	0.900

2012 – 2018	1	33	22	1.022	1.799	0.840
2012 – 2018 – EFFCH	6	25	25	1.018	1.767	0.912
2012 – 2018 – TECHCH	0	33	23	1.004	1.147	0.836
2012 – 2018 – PECH	14	25	17	1.011	1.196	0.896
2012 – 2018 – SECH	7	22	27	1.007	1.767	0.913

Source: Research Data.

In the 2013 – 2014 panel, 25 universities had an increase in productivity and 31 had a decrease. UFOPA presented the best score among the universities that increased productivity, with an increase of 18% (1.180), whereas, among those that decreased productivity, UFRR presented the worst score (0.856). In general, from 2013 to 2014, there was an increase in the productivity of the universities by 1% (0.990). In this period, the inputs CC, NPE, NFE and IQCD increased, respectively, by 10%, 3%, 2% and 1%, while the scores for the RUF increased only by 4% and the scores for the IGC remained unchanged.

For the 2014 – 2015 panel, there was an involution of 0.6% in the productivity of the universities (0.994). The inputs CC, NPE and IQCD increased, respectively, by 6%, 4% and 1%; however, the scores for the RUF declined by 1% and the scores for the IGC remained unchanged. 16 universities had an evolution in productivity and 40 had involution. UFOPA remained the highlight, with an increase of 97.5% in productivity (1.975). UFCSPA, in turn, had the worst productivity score, with a decrease of 14.6% (0.854).

In the 2015 – 2016 panel, the drop in the total productivity of the universities continued, with an involution of 0.3% (0.997). In this period, the CC, NPE, and IQCD inputs increased by 10%, 3% and 1%, respectively, while the IGC and RUF scores increased by only 1% and 4%, respectively. Three universities showed no change in productivity (UFRJ, UFSM and Unifei), 21 had an increase and 32 had a decrease. Among those that had an increase, UFRA stood out, with an increase of 27.5% (1.275) in productivity, while UFRRJ had the worst result among those that presented a drop in productivity, with an involution of 13.7% (0.863).

The 2016 – 2017 panel showed that productivity of the universities continued to decrease, with an involution of 0.8% (0.992). In the period, the inputs CC, NPE, and IQCD increased, respectively, by 8%, 2% and 1%, while the NFE decreased by 4%. However, the IGC scores increased by only 1% and the RUF remained unchanged. Two universities remained at constant productivity (UFSC and UFV). Of the 21 universities that increased productivity, UFOPA stood out with the best score, with an increase of 12.3% (1.123), while UFRB obtained the worst result, with an involution of 11.3% (0.887), among the 33 universities that decreased productivity.

The results for the 2017 – 2018 panel showed that there was a drop in the productivity of the universities, given the involution of 1.4% (0.986). In this period, the inputs CC, NPE, and IQCD increased, respectively, by 3%, 2% and 1%. The scores for the RUF increased by only 1% and the IGC remained unchanged. Of the12 universities that increased productivity, UFAC stood out with the best score, with an evolution of 7.2% (1.072). Ufal had the worst result among the 44 universities that decreased productivity, with a 10% involution (0.900).

Finally, a panel analysis was carried out for the entire period (2012-2018), in order to verify the change in productivity from the first year to the last. Thus, from 2012 to 2018, there was an increase in the total productivity of universities by 2.2% (1.022), that is, in general, there was an improvement in the relation between the quality results of universities and the inputs used. In this period, only one university (Ufma) maintained its productivity constant, while 33 had an increase in productivity and 22 had a decrease. Of the institutions with increased productivity, Ufopa obtained the best result, with an increase of 79.9% (1.799). Among the universities with a drop in productivity, UFRB stood out with the worst result, with a 16% involution (0.840).

The decomposition of the Malmquist Index showed an increase of 2.2 % in productivity, from 2012 to 2018, which occurred in a greater proportion due to the catch-up effect (1.018) and in a lower proportion by the frontier shift effect (1.004). Of the 2.2% evolution in productivity, 1.8% was due to the increase in relative efficiency, that is, the universities approached the efficiency frontier (catch-up effect), and 0.4% was due to the increase in technology, that is, there was an increase in the level of knowledge about the transformation of inputs into outputs (frontier shift effect). In addition, of the 1.8% increase in relative efficiency, 1.1% was due to the increase in pure technical efficiency (1.011), under variable returns to scale, and 0.7% (1.007) was due to the increase scale efficiency.

Table 7 shows the original and projected values for the quality indicators of the universities and for the inputs used, in 2012 and 2018. It is worth remembering that, despite the output-oriented model, reductions were projected for some inputs. According to these values, it was possible to know the percentage variation of waste; in other words, it was verified the level of waste for each input, as well as the level of improvement expected for each output, in order to reach the efficiency frontier.

Table 7 – Original and Projected Values for Outputs and Inputs of Federal Universities (2012 and 2018)

	IGC			RUF		
Year	**Original**	**Projected**	**Dif. %**	**Original**	**Projected**	**Dif. %**
2012	189,54	204,04	8%	2857,73	3053,34	7%
2018	195,15	208,60	7%	3832,50	4114,62	7%
	CC (R$)			**NPE**		
Year	**Original**	**Projected**	**Dif. %**	**Original**	**Projected**	**Dif. %**
2012	R$ 18.352.333.216,07	R$ 17.622.298.115,85	-4%	69556,00	63275,76	-9%
2018	R$ 32.346.751.850,89	R$ 29.957.596.706,07	-7%	84234,00	75984,14	-10%
	NFE			**IQCD**		
Year	**Original**	**Projected**	**Dif. %**	**Original**	**Projected**	**Dif. %**
2012	103076,41	95827,40	-7%	229,02	229,02	0%
2018	115303,13	114188,73	-1%	246,75	246,03	0%

Source: Research Data.

The results showed that, in 2012, given the resources available, federal universities had the potential to increase, together, 8% and 7% in the scores of the IGC and the RUF, respectively. Regarding the inputs, the federal universities together spent approximately 18.352 billion reais. According to the projected values, they should operate with an approximate value of 17.622 billion reais to improve technical efficiency. It was verified a waste of approximately 730 million reais (4%) in 2012. As for professors, the value projected for the NPE was 63275.76, indicating a waste of 9%. Regarding the administrative staff, the projected NFE was 95827.40, indicating a waste of 7%. For the IQCD, there were no excesses.

As for 2018, there was no big difference in relation to 2012 for the outputs, since the difference between the projected and original values for the IGC and RUF indicators was 7% for both. In relation to inputs, the federal universities spent, together, approximately 32.347 billion reais. According to the projected values, they should operate with an approximate value of 29.958 billion reais, indicating a waste of approximately 2.389 billion reais (7%) in 2018. In relation to the professors, the value projected for the NPE was 75984.14, indicating a waste of 10%. Regarding the administrative staff, there was a big difference when compared to 2012, since the projected NFE was 114188.73, indicating a waste of only 1%. Finally, for the IQCD there were also no significant excesses.

However, it is worth noting that, although the projections have indicated the level of waste for the CC, NPE and NFE inputs, these are not subject to discretionary reductions in practice, since the budget of federal universities is fixed by law, as well as the process for dismissing professors and employees is defined by certain legal provisions.

DISCUSSION

The DEA BCC model proved to be appropriate for evaluating the technical efficiency of universities of different sizes, a view also shared by Belloni (2000). However, as pointed out in the results section, it is important to highlight that this model can be benevolent with very small or very large institutions.

Corroborating with Costa *et al*. (2012), there were high levels of technical efficiency during the years under analysis. The results found indicated that, for the country as a whole, the average technical efficiency of federal universities was 93.7%, in 2012, with 17 efficient universities, and 94.5%, in 2018, with 18 efficient universities. This implies that in 2012, given the available inputs, the average of the outputs could be 6.3% higher. In 2018, there was an improvement in results, given that the average of the outputs could be 5.5% higher. In 2013, 2014 and 2017, the technical efficiency averages were 95.5%, 95.4% and 94.7%, in that order. In addition, the years 2015 and 2016 stood out (with 28 and 27 efficient universities respectively), whose national averages were 96.1%.

Nevertheless, it is worth noting that, due to the benevolence of the BCC model with very small or very large units, as well as with units with the lowest value for a given input or the highest value for a given output, universities such as UFRJ, UFRGS, UFMG, Unifap, Ufopa, UFCSPA and Ufra may have been considered efficient by default. Among the efficient universities throughout the entire period, Ufscar and Ufla stood out as a benchmark for the universities that were below the efficiency frontier.

In the analysis by region, it was found that, between 2012 and 2018, the Southeast region was the one that covered the largest number of efficient universities. Then, the North region was the second that contained more efficient universities. The third and fourth positions were occupied by the Northeast and South regions, respectively; and finally, the Midwest region stood out for having the lowest number of efficient universities. Thus, based on this regional distribution, it was clear that there was no concentration of efficient universities in the most developed regions of the country, a result also pointed out by Rolim *et al*. (2020).

Through the analysis of the Malmquist Index, it was found that, from 2012 to 2013, there was an increase in the productivity of universities by 6.4%. In the panel analysis by pairs of years from 2013 to 2018, it was verified that, in general, there was a drop in the productivity of federal universities, with emphasis on the panel 2017-2018, whose involution in productivity was 1.4%. However, in contrast to the results in Costa *et al*. (2015), in the panel analysis for the entire period, it was found that, from 2012 to 2018, there was an increase in the productivity of the universities by 2.2%, that is, in general, there was an improvement in the relation between the quality results of the universities and the inputs used.

In this period, only one university kept its productivity constant, while 33 had an increase in productivity and 22 had a decrease. In addition, the decomposition of the Malmquist Index showed that the increase in productivity of universities, from 2012 to 2018, occurred in a greater proportion due to the catch-up effect (1.8%) and in a lower proportion by the frontier shift effect (0.4%). Furthermore, the increase of 1.8% in relative efficiency occurred in a greater proportion due to the increase in pure technical efficiency (1.1%) and in a lower proportion due to the increase in scale efficiency (0.7%).

This increase in productivity could be verified in large part by the reduction of the waste rate of the input NFE. When comparing the original and projected values for the inputs used, the NFE projected for 2012 was 95827.40, indicating a waste of 7%. In 2018, the projected NFE was 114188.73, indicating a waste of only 1%. However, it is important to point out that, despite the increase in productivity, federal universities together spent approximately 32.347 billion reais in 2018. According to the projected values, they should operate with an approximate value of 29.958 billion reais, which indicates a waste of about 2.389 billion reais (7%). Thus, in line with Rolim *et al*. (2020), in order to expand the rationality of the resources applied and to achieve better efficiency scores in 2018, it would be necessary, in addition to expanding the quality results, to reduce the current cost, and the number of professors and employees.

CONCLUSION

This research aimed to analyze the level of technical efficiency of Brazilian federal universities, from 2012 to 2018, using the Data Envelopment Analysis (DEA) method, in the search to identify efficient universities from the relations between the inputs used (Current Cost, Number of Equivalent Professors, Number of Equivalent Employees and Faculty Qualification Index) and the quality results of these institutions (General Course Index and University Ranking of *Folha*).

It was concluded that the proposed objectives were achieved, since it was possible to identify that there were high levels of technical efficiency among the Brazilian federal universities during the years under analysis. As for the first specific objective, the results indicated that technical efficiency of federal universities was 93.7% in 2012 and 94.5% in 2018. This implies that in 2012, given the available inputs, the average of the outputs could be 6.3% higher. In 2018, there was an improvement in results, since the average of the outputs could be 5.5% higher. In 2013, 2014 and 2017, the technical efficiency was 95.5%, 95.4% and 94.7%, in that order, and the years 2015 and 2016 stood out with a technical efficiency of 96.1%.

In the analysis by region, it was found that, between 2012 and 2018, the Southeast region was the one that covered the largest number of efficient universities. Nevertheless, the

Midwest region stood out for having the lowest number of efficient universities. Thus, based on this regional distribution, it was clear that there was no concentration of efficient universities in the most developed regions of the country.

As for the second specific objective, it was identified that, in 2012, Ufam stood out as a benchmark for institutions considered inefficient, being a reference for 27 universities. In 2013, this place was occupied by UFTM, which was benchmark for 16 institutions considered inefficient. In 2014, UFV and Ufam stood out for being a reference for 21 and 14 institutions, respectively. As for 2015, UFV was a benchmark for 18 universities located below the frontier, and, in 2016, the emphasis was on UFCG, which was a benchmark for 11 institutions. In 2017, UFCG and UFCSPA stood out for being a reference for 29 and 20 inefficient institutions, in that order, and, in 2018, this place was occupied by Ufla, which was reference for 26 universities considered inefficient.

Finally, it was possible to verify the changes in productivity of the universities, over the period under analysis, through the Malmquist Index (MI). From 2012 to 2018, there was an increase in the productivity of the universities by 2.2%, that is, in general, there was an improvement in the relation between the quality results of the universities and the inputs used. In this period, the increase in productivity of universities occurred in a greater proportion due to the catch-up effect (1.8%) and in a lower proportion by the frontier shift effect (0.4%). Furthermore, the increase of 1.8% in relative efficiency occurred in a greater proportion due to the increase in pure technical efficiency (1.1%) and in a lower proportion due to the increase in scale efficiency (0.7%).

Given the current Brazilian context of economic crisis and the inevitability of contingency of public spending, it is essential to reduce the waste of resources, so that they can be used more efficiently. The results obtained here pointed out that, despite the improvement in productivity, there is still room to achieve better quality results and improvements in the management of resources, in order to reduce waste.

Therefore, it is expected, with this research, in addition to contributing to the literature on the evaluation of the efficiency of IES, to assist public managers in the search for better management practices of public resources, in order to achieve better quality results and more federal universities technically efficient. Given the relevance of the theme, it is expected that the discussion will not end here, but that the advances in this study will serve as an incentive to carry out new research, including with different approaches, providing additional information relevant to the study on the efficiency of federal universities.

REFERENCES

BANKER, R. D.; CHARNES A.; COOPER, W. W. Some models for estimation technical and scale inefficiencies in Data Envelopment Analysis. *Management Science*, v. 30, n. 9, p. 1.078-1.092, 1984.

BARBOSA, G. C.; FREIRE, F. S.; CRISÓSTOMO, V. L. Análise dos indicadores de gestão das IFES e o desempenho discente no ENADE. *Avaliação (Campinas)*, Sorocaba, v. 16, n. 2, p. 317-343, 2011.

BELLONI, J. A. *Uma metodologia de avaliação da eficiência produtiva de universidades federais brasileiras*. 2000. 245 f. Tese (Doutorado em Engenharia de Produção) – Universidade Federal de Santa Catarina, Florianópolis, 2000.

BITTENCOURT, H. R.; CASARTELLI, A.; MORAIS, A. Sobre o índice geral de cursos (IGC). *Avaliação (Campinas)*, Sorocaba, v. 14, n. 3, p. 667-682, 2009.

BRASIL. *Lei n. 10.861, de 14 de abril de 2004*. Institui o Sistema Nacional de Avaliação da Educação Superior – SINAES e dá outras providências. 2004. Available from: http://www.planalto.gov.br/ccivil_03/_ato2004-2006/2004/lei/l10.861.htm. Access on: 2 Mar. 2020.

BRASIL. TCU – Tribunal de Contas da União; Secretaria de Educação Superior/MEC; Secretaria Federal de Controle Interno. *Orientações para o cálculo dos indicadores de gestão:* decisão plenária n° 408/2002 e acórdão nº 1.043/2006. 2006. Available from: http://www.ufc.br/a-universidade/avaliacao-instituciona-l/340-orientacoes-paracalculo-de-indicadores-de-gestao-do-tcu. Access on: 27 Feb. 2020.

CHARNES, A.; COOPER, W. W.; RHODES, E. Measuring the efficiency of decision-making units. *European Journal of Operational Research*, v. 2, n. 6, p. 429-444, 1978.

COSTA, E. M. *Financiamento, alocação de recursos e eficiência das Instituições Federais de Ensino Superior – IFES*. 2010. 172f. Tese (Doutorado em Economia) – Universidade Federal de Pernambuco, Recife, 2010.

COSTA, E. M.; RAMOS, F. S.; SOUZA, H. R.; SAMPAIO, L. M. B.; BARBOSA, R. B. Dinâmica da eficiência produtiva das instituições federais de Ensino Superior. *Planejamento e Políticas Públicas – PPP*, Brasília, n. 44, 2015.

COSTA, E. M.; SOUZA, H. R.; RAMOS, F. S.; SILVA, J. L. M. Eficiência e desempenho no Ensino Superior: uma análise da fronteira de produção educacional das IFES brasileiras. *Revista de Economia Contemporânea*, Rio de Janeiro, v. 16, n. 3, p. 415-440, 2012.

COELLI, T.; RAO, D. S. P.; O'DONNEL, C. J.; BATTESE, G. E. 2. ed. *An introduction to efficiency and productivity analysis*. Boston, MA: Springer US, 2005.

DYSON, R. G.; ALLEN, R.; CAMANHO, A. S.; PODINOVSKI, V. V.; SARRICO, C. S.; SHALE, E. A. Pitfalls and protocols in DEA. *European Journal of Operational Research*, v. 132, p. 245-259, 2001.

FÄRE, R.; GROSSKOPF, S.; LINDGREN, B.; ROOS, P. Productivity developments in Swedish hospitals: a Malmquist output index approach. *In*: CHARNES, A.; COOPE, W. W.; LEWIN, A. Y.; SEIFORD, L. M. (org.). *Data envelopment analysis*: theory, methodology, and application. New York: Springer Science; Business Media, 1994. p. 253-272.

FARRELL, M. J. The measurement of productive efficiency. *Journal Royal Statistical Society*, v. 120, Part III, p. 253-290, 1957.

INEP. Instituto Nacional de Estudos e Pesquisas Educacionais Anísio Teixeira. *Nota técnica DAES/INEP n. 35/2016*. 2016. Available from: https://download.inep.gov.br/educacao_superior/enade/notas_tecnicas/2014/nota_tecnica_daes_n_35_2016_estudo_sobre_calculo_do_igc_2014.pdf. Access on: 2 Mar. 2020.

JI, Y. B.; LEE, C. Data envelopment analysis. *The Stata Journal*, v. 10, n. 2, p. 267-280, 2010.

LOBO, M. S. C.; SILVA, A. C. M.; LINS, M. P. E.; FISZMAN, R. Impacto da reforma de financiamento de hospitais de ensino no Brasil. *Revista de Saúde Pública*, São Paulo, v. 43, p. 437-445, 2009.

MARIANO, E. B.; ALMEIDA, M. R.; REBELATTO, D. A. N. Peculiaridades da análise por envoltória de dados. *In*: SIMPÓSIO DE ENGENHARIA DE PRODUÇÃO – SIMPEP, 12., 2006. Bauru. *Anais* [...]. Bauru: Unesp, 2006.

MARTINEZ COHEN, M. A.; PAIXÃO, A. N.; OLIVEIRA, N. M. Eficiência nas universidades federais brasileira: uma aplicação da análise envoltória de dados. *Informe Gepec*, [*S.l.*], v. 22, n. 1, p. 133-149, jul. 2018.

MELLO J. C. B. S.; MEZA, L. A.; GOMES, E. G.; BONDI NETO, L. Curso de análise de envoltória de dados. *In*: SIMPÓSIO BRASILEIRO DE PESQUISA OPERACIONAL – SBPO, 37., 2005, Gramado. *Anais* [...]. Gramado: [*s.n.*], 2005. p. 2.520-2.547.

NUINTIN, A. A. *Eficiência da aplicação de recursos públicos nas universidades federais*. 2014. 169 f. Tese (Doutorado em Administração) – Universidade Federal de Lavras, Lavras 2014.

OECD. Organisation for Economic Co-Operation and Development. *Education at a Glance 2020*. 2020. Available from: https://www.oecd.org/education/education-at-a-glance. Access on: 10 Aug. 2020.

OLIVEIRA, C.; TURRIONI, B. Avaliação de desempenho de instituições federais de ensino superior através da análise envoltória de dados (DEA). *In*: XXVI Encontro Nacional De Engenharia De Produção, 26., 2006. Fortaleza. *Anais* [...]. Fortaleza: [*s.n.*], 2006. p. 1-8.

PARENTE, P. H. N.; MARIA, C. C. de; DUTRA, R. S.; PAULO, E. Eficiência e produtividade nos Institutos Federais de Educação, Ciência e Tecnologia do Brasil. *Administração Pública e Gestão Social*, v. 13, n. 1, 2021.

ROLIM, L. F.; CAVALCANTI DE ALMEIDA, A. T.; COÊLHO LOMBARDI FILHO, S.; RODRIGUES DOS ANJOS JÚNIOR, O. Avaliação da eficiência dos gastos das instituições federais de Ensino Superior brasileiras. *Teoria e Prática em Administração*, v. 11, n. 1, p. 1-16, 2020.

ROSANO-PEÑA, C.; ALBUQUERQUE, P. H. M.; MARCIO, C. J. A eficiência dos gastos públicos em educação: evidências georreferenciadas nos municípios goianos. *Economia Aplicada*, Ribeirão Preto, v. 16, n. 3, p. 421-443, 2012.

RUF. Ranking Universitário Folha. *Como é feito o ranking universitário folha*. 2019. Available from: https://ruf.folha.uol.com.br/2019/noticias/como-e-feito-o-ranking-universitario-folha.shtml. Access on: 27 Feb. 2020.

SOARES, J. R.; BORDIN, R; ROSA, R. S. Indicadores de gestão e de qualidade nas instituições federais de Ensino Superior brasileiras – 2009 a 2016. *Revista Eletrônica de Administração*, Porto Alegre, v. 25, n. 2, p. 215-239, 2019.

TAVARES, R. S.; MEZA, L. A. Determinação da eficiência de cursos de engenharia de uma instituição federal de Ensino Superior. *In*: SIMPÓSIO BRASILEIRO DE PESQUISA OPERACIONAL – SBPO, 47., 2015, Porto de Galinhas. *Anais* [...]. Porto de Galinhas: [*s.n.*], 2015. p. 770-781.

APPENDIX A – CORRELATION BETWEEN THE MANAGEMENT AND QUALITY INDICATORS OF THE FEDERAL UNIVERSITIES FROM 2012 TO 2018

Table A.1 – Spearman's Correlation between the Management and Quality Indicators

Correlation between the Management Indicators and the General Course Index (IGC)							
Indicator	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**
CC	0,3750**	0,4484**	0,5211**	0,5204**	0,5109**	0,5576**	0,5861**
	(0,0044)	(0,0005)	(0,0000)	(0,0000)	(0,0001)	(0,0000)	(0,0000)
CCAE	0,2028	0,2141	0,2288	0,3671**	0,1478	0,0280	0,1014
	(0,1339)	(0,1130)	(0,0899)	(0,0054)	(0,2769)	(0,8379)	(0,4573)
NPE	0,2718*	0,3275*	0,4014**	0,3776**	0,4030**	0,4563**	0,4707**
	(0,0427)	(0,0138)	(0,0022)	(0,0041)	(0,0021)	(0,0004)	(0,0003)
ATIPE	0,2173	0,3485**	0,4041**	0,2874*	0,4237**	0,5261**	0,5051**
	(0,1076)	(0,0085)	(0,0020)	(0,0317)	(0,0011)	(0,0000)	(0,0001)
NFE	0,3201*	0,4017**	0,4694**	0,4241**	0,4468**	0,5187**	0,5781**
	(0,0162)	(0,0022)	(0,0003)	(0,0011)	(0,0006)	(0,0000)	(0,0000)
ATIFE	-0,1507	-0,0899	0,0805	0,0835	0,1692	0,1236	-0,0153
	(0,2676)	(0,5100)	(0,5554)	(0,5407)	(0,2124)	(0,3640)	0,9108
FEPE	0,3160*	0,3589**	0,2889*	0,1811	0,2873*	0,2950*	0,4669**
	(0,0177)	(0,0066)	(0,0308)	(0,1817)	(0,0318)	(0,0273)	(0,0003)
GPE	0,2431	0,0722	0,0996	-0,1346	-0,1385	0,0970	0,0992
	(0,071)	(0,5968)	(0,4651)	(0,3225)	(0,3086)	(0,477)	(0,4670)
GEPG	0,6702**	0,7251**	0,7660**	0,7604**	0,7808**	0,8266**	0,8345**
	(0,0000)	(0,0000)	(0,0000)	(0,0000)	(0,0000)	(0,0000)	(0,0000)
CAPES	0,7192**	0,7179**	0,7782**	0,7800**	0,8000**	0,8555**	0,8665**
	(0,0000)	(0,0000)	(0,0000)	(0,0000)	(0,0000)	(0,0000)	(0,0000)
IQCD	0,7935**	0,7980**	0,7935**	0,7773**	0,8013**	0,8181**	0,7988**
	(0,0000)	(0,0000)	(0,0000)	(0,0000)	(0,0000)	(0,0000)	(0,0000)
TSG	0,3624**	0,3913**	0,2749*	0,2606	0,1839	0,3240*	0,2828*
	(0,0060)	(0,0029)	(0,0403)	(0,0524)	(0,1749)	(0,0148)	(0,0347)
Correlation between the Management Indicators and the University Ranking of *Folha* (RUF)							
Indicator	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**
CC	0,9029**	0,8625**	0,8887**	0,8887**	0,8643**	0,8556**	0,8552**
	(0,0000)	(0,0000)	(0,0000)	(0,0000)	(0,0000)	(0,0000)	(0,0000)
CCAE	0,0628	0,2211	0,1023	0,1485	0,0179	-0,0175	-0,0041
	(0,6456)	(0,1016)	(0,4533)	(0,2746)	(0,8956)	(0,8981)	(0,9761)
NPE	0,8401**	0,7810**	0,8203**	0,8234**	0,8090**	0,7971**	0,7969**
	(0,0000)	(0,0000)	(0,0000)	(0,0000)	(0,0000)	(0,0000)	(0,0000)
ATIPE	0,5873**	0,5585*	0,6813**	0,4862**	0,6592**	0,6191**	0,5966**
	(0,0000)	(0,0000)	(0,0000)	(0,0001)	(0,0000)	(0,0000)	(0,0000)
NFE	0,8645**	0,8323**	0,8565**	0,8580**	0,8452**	0,8237**	0,8664**
	(0,0000)	(0,0000)	(0,0000)	(0,0000)	(0,0000)	(0,0000)	(0,0000)
ATIFE	0,1727	0,0953	0,3773**	0,2416	0,2501	0,1945	0,0905
	(0,2032)	(0,4850)	(0,0041)	(0,0728)	(0,0630)	(0,1509)	(0,5071)
FEPE	0,2022	0,3416**	0,1573	0,107	0,2578	0,2927*	0,4057**
	(0,135)	(0,0100)	(0,2469)	(0,4327)	(0,0551)	(0,0286)	(0,0019)
GPE	0,4378**	0,1624	0,1359	-0,0706	-0,0094	0,0582	0,1322
	(0,0007)	(0,2317)	(0,318)	(0,6051)	(0,9451)	(0,6702)	(0,3316)
GEPG	0,8344**	0,8039**	0,8075**	0,8405**	0,8347**	0,7445**	0,7810**
	(0,0000)	(0,0000)	(0,0000)	(0,0000)	(0,0000)	(0,0000)	(0,0000)
CAPES	0,8404**	0,8415**	0,7638**	0,7413**	0,7464**	0,8146**	0,8495**
	(0,0000)	(0,0000)	(0,0000)	(0,0000)	(0,0000)	(0,0000)	(0,0000)
IQCD	0,5421**	0,6193**	0,5681**	0,5512**	0,5268**	0,5989**	0,5543**
	(0,0000)	(0,0000)	(0,0000)	(0,0000)	(0,0000)	(0,0000)	(0,0000)
TSG	0,4352**	0,4261**	0,4027**	0,3920**	0,3666**	0,3966**	0,3541**
	(0,0008)	(0,0011)	(0,0021)	(0,0028)	(0,0055)	(0,0025)	(0,0074)

Note: Significance in parentheses, with $p < 0{,}05$ = * and $p < 0{,}01$ = **; CC – Current Cost; CCAE – Current Cost/Equivalent Student; NPE – Number of Equivalent Professors; Atipe – Full Time Student/Number of Equivalent Professors; NFE – Number of Equivalent Employees; Atife – Full Time Student/Number of Equivalent Employees; Fepe – Number of Equivalent Employees/Number of Equivalent Professors; GPE – Level of Students Participation; GEPG – Level of Involvement in Graduate Programs; Capes – Concept for the Master's and Doctoral courses; IQCD – Faculty Qualification Index; TSG – Undergraduate Success Rate.

Source: Research Data.