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The effects of adopting sustainable practices on consumption indicators in public management

Os efeitos da adoção de práticas sustentáveis nos indicadores de consumo na gestão pública

Los efectos de la adopción de prácticas sostenibles sobre los indicadores de consumo en la gestión pública

Maria Rosineide Cavalcante Bittencourt
Fucape Business School
Av. Fernando Ferrari, 1358, Boa Vista, Vitória – ES, CEP: 29.075-505
https://orcid.org/0000-0002-6310-1883
rosa_alagoas@hotmail.com

Valcemiro Nossa
Fucape Business School
Av. Fernando Ferrari, 1358, Boa Vista, Vitória – ES, CEP: 29.075-505
https://orcid.org/0000-0001-8091-2744
valcemiro@fucape.br

KEYWORDS
Environment and Sustainable Practices. Federal Institutes of Education. Sustainable Logistics Plan.

Abstract: Sustainability is a much discussed subject nowadays, motivated by growing concerns with disruptions to the environment and the resulting social and economic issues. The Federal Institutes (FIs) are part of the public administration of Brazil, and are involved in the implementation of sustainable practices. This paper aims to verify the relationship between the implementation of the Sustainable Logistics Plan (PLS) in FIs in Brazil, with the variation of expenditure on energy and water, and role of Federal Higher Education Institutions (HEIs), in the period from 2014 to 2019. Data collection used documents from the Management Reports PLS of the analyzed Institutions; observing the sustainability actions adopted in the 38 rectories that make up the FIs in in all Brazilian state capitals; as well as documents on the Transparency portals, on the Ministry of the Environment website, on the Brazilian Open Data Portal, and on the Fala.Br website, which is a quantitative study using a panel multiple linear regression model with random effect, whose results indicated that there is no reduction in the percentage change in energy, office supplies, and water and sewage expenses.

PALAVRAS-CHAVE
Meio Ambiente e Práticas Sustentáveis. Institutos Federais de Educação. Plano de Logística Sustentável.

Resumo: *A sustentabilidade é um assunto muito discutido na atualidade, motivada pela crescente preocupação com o meio ambiente e suas questões sociais e econômicas. Os Institutos Federais (IFs) fazem parte da administração pública e estão envolvidos na implantação das práticas sustentáveis. Esta pesquisa tem como objetivo verificar a relação entre a implantação do Plano de logística Sustentável (PLS) nos IFs do Brasil, com a variação das despesas com energia, água, e papel dessas IES, no período de 2014 a 2019. A coleta de dados utilizou documentos do PLS de Relatórios de Gestão das Instituições analisadas; observando as ações de sustentabilidade adotadas nas 38 Reitorias que compõem os IFs do Brasil em todas as capitais; e de documentos nos portais da Transparência, no site do Ministério do Meio Ambiente, Portal Brasileiro de Dados Abertos, e no site Fala.Br, sendo uma pesquisa quantitativa com o modelo de regressão linear múltipla em painel com efeito aleatório, cujos resultados apontaram que não há redução da variação percentual de gastos com energia, materiais de escritório, e água e esgoto.*

PALABRAS CLAVE
Medio Ambiente y Prácticas Sostenibles. Institutos Federales de Educación. Plan Logístico Sostenible.

Resumen: *La sostenibilidad es un tema muy discutido en la actualidad, motivado por la creciente preocupación por el medio ambiente y sus problemas sociales y económicos. Los Institutos Federales (IFs) son parte de la administración pública y están involucradas en la implementación de prácticas sostenibles. Esta investigación tiene como objetivo verificar la relación entre la implementación del Plan de Logística Sostenible (PLS) en las IF de Brasil, con la variación del gasto en energía, agua y rol de estas IES, en el período de 2014 a 2019. Recolección de datos utilizados documentos de los Informes de Gestión PLS de las Instituciones analizadas; observar las acciones de sustentabilidad adoptadas en la 38 Rectoría que integran las IF de Brasil en todas las capitales; y documentos en los portales de Transparencia, en el sitio web del Ministerio del Medio Ambiente, Portal Brasileño de Datos Abiertos, y en el sitio web Fala.Br, que es una investigación cuantitativa con un modelo de regresión lineal múltiple de panel con efecto aleatorio, cuyos resultados indicaron que existe sin reducción en el cambio porcentual en energía, suministros de oficina y gastos de agua y alcantarillado.*

Introduction

Over time, the debate on sustainable development has gained global relevance, and society has increasingly understood the need to adopt sustainable practices to care for and preserve the environment (Guimarães Severo & Vasconcelos, 2017; Tseng, Islam, Karia, Fauzi & Afrin, 2019; Barros, Puglieri, Tesser, Kuczynski & Piekarski, 2020; Banerjee, Gupta & Mudalige, 2020; Kitsios, Kamariotou & Talias, 2020; Choudhary, Kumar, Luthra, Garza-Reyes & Nadeem, 2020; Hameed, Hyder, Imran & Shafiq, 2021; Lemke, 2021).

According to Benites (2019), Public Administration has the obligation to implement and develop environmental public policies which consider society's well-being while preserving natural resources and the environment. In this sense, the author believes that public agencies, as large consumers of goods and services, need to set an example of good sustainability practices in their activities. For Luchtemberg and Assunção (2020), it is necessary for Public Management to adopt sustainable principles, moving from theoretical discourse to practice through Action Plans. According to these authors, for attitude changes to occur within public agencies, all involved participants must collaborate with the transformation, as they are important allies in implementing sustainable development actions.

According to Tseng, Islam, Karia, Fauzi, and Afrin (2019), Bux, Zhang, and Ahmad (2020), Kitsios, Kamariotou, and Talias (2020), Choudhary, Kumar, Luthra, Garza-Reyes, and Nadeem (2020), Carter, Jayachandran, and Murdock (2021), and Hameed, Hyder, Imran, and Shafiq (2021), public and private managers are already aware of the importance of formulating a corporate sustainability strategy but face difficulties in its implementation. Kitsios et al. (2020) emphasize that the implementation and monitoring of a sustainability strategy is a challenging issue because each organization has specific characteristics. Additionally, Nossa, Rodrigues, and Nossa (2017) state that there are many gaps, especially regarding verifying the performance of sustainable practices adopted by companies.

Studies by Barros, Puglieri, Tesser, Kuczynski, and Piekarski (2020) highlight that Federal Higher Education Institutions (HEIs) have a commitment not only to education but also to sustainable development. They state that sustainable development goals support various actions which universities and institutes can take on as principles and attitudes. Moreover, federal higher education public agencies can use scientific techniques and adapt practices to improve environmental sustainability and develop students' environmental awareness in their academic formation.

In this context, the research is centered in Brazil due to its indicators for the Sustainable Development Goals (SDGs) adapted to the Sustainable Logistics Plan (PLS), which are the objects of our research. According to Miola and Schiltz (2019), when indicators are related to the country's scenario, they become more suitable for a detailed study on the adoption of sustainable practices, providing a more consistent data source to evaluate environmental, economic, and social performance in institutions.

In the literature, some works study the implementation of PLS by public agencies, such as those by Benites (2019) and Lellis (2020). However, these authors do not clarify whether there was a reduction in expenses with the adoption of sustainable practices since the necessary monitoring and follow-up were not always conducted. Thus, analyzing the relationship between spending on energy, water, and paper and sustainability actions by FIs addresses a research gap. Therefore, this paper asks: What is the relationship between the adoption of the Sustainable Logistics Plan and expenses on water, energy, and paper in the Federal Institutes of Education, Science, and Technology of Brazil?

This study aims to verify the relationship between implementing the Sustainable Logistics Plan (PLS) in the Federal Institutes of Education, Science, and Technology (FIs) with the variation in expenses on energy, water, and paper of these institutions from 2014 to 2019. To answer this research, 38 Federal Institutes of Science and Technology in Brazil were analyzed, and the sample was divided into two groups: a treatment group (Institutes that implemented the PLS) and a control group (Institutes that did not implement the PLS). The study's temporal limitation is the years 2014 to 2019, as these are the years with data disclosed until the preparation of this analysis. A

quantitative and descriptive research approach was adopted using a multiple linear regression model estimated in a panel with fixed and random effects, with a total of 178 final observations.

The research is relevant as it aims to relate sustainability practices through the PLS with expenses on energy, water, and paper, allowing an analysis of the effects of adopting these practices in public agencies, particularly in the Federal Institutes of Education, Science, and Technology in Brazil.

Thus, the research hypotheses are proposed, affirming that Federal Teaching Institutes that adopted sustainable practices through the PLS—influenced by social and economic variables—had reduced energy, water, and paper consumption as they established and monitored their sustainability actions. However, the results of this study reveal that there were no significant associations between implementing the Sustainable Logistics Plan in the Brazilian FIs and reducing expenses on energy, water, or office supplies, despite the increase in the number of PLS adopters per year within the Federal public sector.

This research provides a theoretical contribution by fostering discussions about the relationship between adopting sustainable practices by higher education public agencies and the effects on the variation in their expenses on water, energy, and paper, besides using the PLS as a comparison tool for monitoring the implementation of these practices. Additionally, this study contributes by showing that many FIs have not yet implemented the Sustainable Logistics Plan (PLS), and these results allow public managers to observe the actual situation of these agencies, re-evaluating the environmental management practices adopted. Socially, the research serves as an alert for the need for more effective execution of sustainability plans, promoting a critical reflection on environmental practices in federal institutes, which can influence future policies and practices in educational institutions and other government agencies.

Theoretical elements of research

Sustainable practices

In the Brundtland Report of 1987, the concern for future generations and the environment was the subject of many debates, and since then, environmental, social, and economic issues have been discussed by various authors. According to Silva (2020) and Conceição (2020), it was from the 1970s that several global events began—part of a worldwide effort to seek sustainable development—such as the United Nations Conference on the Human Environment held in Stockholm (1972), the Kyoto Protocol (1997), the UN Rio+20 Conference and The Future We Want (2012), among others. According to Corrêa and Ashley (2018), the topic of Environmental Education was included in the educational context based on one of these events.

According to Bux et al. (2020) and Kitsios et al. (2020), managers have already recognized the importance of formulating a corporate sustainability strategy but face difficulties concerning the action plan. Nossa et al. (2017) and Kitsios et al. (2020) understand that implementing a sustainability strategy is a challenging issue for companies because each has specific characteristics (for example, the sector, organizational structure, and internal processes, business policy capabilities, stakeholder interests, market changes, external environment effects, etc.).

Reinforcing the topic, Gomes (2020) states that evidence shows that companies with greater growth potential have more opportunities to adopt sustainable practices in their operations. In line with Nossa et al. (2017) and Kitsios et al. (2020), this occurs because larger companies are more subject to stakeholder analysis. Thus, according to Tseng et al. (2019); Barros et al. (2020); Broccardo & Zicari (2020); Kitsios et al. (2020), Choudhary et al. (2020), Carter et al. (2021); Hameed et al. (2021), companies would voluntarily adopt sustainable practices due to the intangible value created by such actions, such as innovation and reputation gains.

According to Townsend (2020) and Rodrigues (2020), good financial performance signals to investors a good opportunity and provides companies with more capacity to improve their environmental and social performance. Therefore, cost reduction and information asymmetry reduction influenced by social responsibility actions have a positive effect on financial performance (Soedjatmiko, Tjahjadi & Soewarno, 2021).

Filimonau and Delysia (2019) and Soedjatmiko, Tjahjadi, and Soewarno (2021)

found evidence that companies invest in sustainability for motives not solely aligned with financial results. These authors demonstrated that companies seek to disclose their commitment to adopting sustainable practices due to external pressures, market survival, and stakeholder pressures, as Soedjatmiko et al. (2021) state that investment in sustainability can increase stakeholder trust in these companies.

Adoption of sustainable practices and the 2030 Agenda

For Allen, Metternicht, and Wiedmann (2019), the 2030 Agenda and its seventeen Sustainable Development Goals (SDGs) were created to monitor and guide sustainable development actions worldwide. Miola and Schiltz (2019) state that choosing indicators and identifying goals can be considered central points for defining SDG performance metrics since many of the objectives established by the 17 SDGs and their 169 targets are not defined in quantitative terms.

According to Miola and Schiltz (2019), world leaders at the historic UN summit in 2015 adopted the Sustainable Development Goals and corresponding targets for 2030 to address the major environmental challenges. They recognized that eradicating poverty requires strategies that align with economic growth, environmental protection, and managing a range of social needs. Benites (2019) understands that the 17 SDGs with 169 targets were designed to be monitored through a set of global indicators adopted along with the 2030 Agenda.

Recent research on the SDGs articulates the gaps and priorities of studies, including research on the nature and dynamics of interactions between the SDGs and the goals to be achieved, establishing clear baselines and metrics to evaluate this process (Shrivastava et al., 2017). According to Allen et al. (2019), this ensures that the interdependencies between the goals are considered in formulating strategies and policies and that coherent decision-making frameworks are used to support prioritization and planning of these indicators.

According to Miola and Schiltz (2019), it is necessary to compare methods that measure the performance of the Sustainable Development Goals (SDGs). Thus, according to Lafortune, Rothstein, and Schanzenbach (2018) and Sachs, Schmidt-Traub, Kroll, Durand-Delacre, and Teksoz (2018), in European Union countries, the Sustainable Development Goals Index developed by the Bertelsmann Stiftung and the Sustainable Development Solutions Network suggests a strong discrepancy in the results found, as, depending on the chosen indicators and applied methods, countries may receive substantially different assessments from those indicated by the OECD (2017).

Saravalli (2020) reports that the UN Statistical Commission is developing a framework of indicators to monitor and report the SDG implementation process worldwide, recognizing that different indicators may be appropriate in diverse contexts.

Allen et al. (2019) adopt a case study as an integrated assessment to support SDG target prioritization in 22 countries in the Arabian region. Their research adopts a multiple-criteria decision analysis framework that evaluates and prioritizes SDG targets based on their urgency, systemic impact, and policy gap. The authors state that a range of evidence-based and science-based approaches are applied within the verification framework, including benchmark evaluation and benchmarking of indicators, systems, and target-linkage network analysis, as well as policy alignment and gap mapping.

Therefore, Silva (2020) understands that since Brazil has sustainable development indicators created by the Sustainable Logistics Plan (PLS), the SDG indicators are more recommended for a detailed analysis of sustainable practices in the country. However, Miola and Schiltz (2019) state that the use of indicators depends on the country's context, as they provide a more consistent data source to assess its performance.

Sustainable logistics management plan

Lemos, Rodrigues, Lagioia, and Libonati (2020) highlight that many actions related to sustainability practices exist in the public sector, such as Normative Instructions, programs, and action plans. At the federal level, the Ministry of the Environment (MMA) plays an important role in dealing with sustainability issues and is responsible for many programs aimed at the environment, such as the Environmental Agenda in Public Administration (A3P) and the Sustainable

Logistics Plan (PLS). They state that implementing the PLS by public agencies has been mandatory since 2013, serving to help adopt sustainability actions in Public Administration.

In Brazil, Decree No. 7,746/2012 regulated sustainable actions in Federal Public Institutions, establishing the creation and adoption of the PLS as mandatory for these agencies. According to Luiz, Pfitscher, and Rosa (2015), the decree determines that the PLS includes, at a minimum, practices for rationalizing the use of goods such as consumables, paper, disposable cups, and services like electricity and water, and when possible, replacing them with materials that have lower environmental impacts.

In Brazilian literature, some works analyze the implementation of the Sustainable Logistics Plans (PLS) by federal public agencies, such as work by Lellis (2020), who investigated the indicators and performance metrics of sustainability in public institutions, and studies by Weber, Machado, Padgett, and Sehnem (2020), Franco, Leite, Cameron, Lopes, and Almeida (2017), and Lins, Paz, Firmo, Soares, and Carvalho (2018), which sought to identify the PLS elaboration process and sustainability actions developed by Brazilian public education institutions. Meanwhile, Pereira (2017) and Benites (2019) directed their research to the implementation of the Sustainable Logistics Plan in Federal Institutes of Education, Science, and Technology.

Figure 1 contains suggestions for Sustainability Practices extracted from Normative Instruction No. 10 of November 12, 2012, referencing the elaboration of PLS.

Figure 1

Themes and practices for developing sustainable logistics plans

Theme	Sustainability Practices
Consumption Materials (divided into Paper, Disposable Cups, and Printer Cartridges)	Use electronic messages (email) for communication, avoiding paper use; replace printed documents with digital documents; print only if necessary; schedule maintenance or replacement of printers for efficiency; print double-sided documents; use recycled paper or paper produced without chlorine substances harmful to the environment; conduct awareness campaigns to reduce paper consumption; prefer cups produced with materials that can be reused or recycled to minimize adverse environmental impacts; prefer to use printing with a text font style that saves ink or toner, etc.
Electricity	Diagnose the condition of electrical installations and propose necessary changes to reduce consumption; monitor energy consumption; conduct awareness campaigns; turn off lights and monitors when leaving the environment; close doors and windows when using air conditioning; review contracts to rationalize based on the real electricity demand of the agency or entity; use motion sensors in transit areas when possible, etc.
Water and sewage	Conduct periodic surveys and monitoring of hydraulic installations and propose necessary changes to reduce consumption; monitor water use; conduct awareness campaigns to prevent water waste; analyze the feasibility of rainwater harvesting, artesian wells; create routines for garden irrigation frequency to standardize periods for this activity in each season; prefer the use of more efficient flushes and faucets, etc.
Selective Collection	Promote the implementation of selective collection following CONAMA Resolution No. 275 of April 25, 2001, or other legislation that replaces it; promote sustainable waste disposal; implement solidary selective collection following Decree No. 5,940 of October 25, 2006, or other legislation that replaces it.
Quality of Life in the Work Environment	Adopt measures to promote a safe and healthy physical work environment; conduct maintenance or replacement of noise-generating equipment in the work environment; promote integration and quality of life activities in the workplace; conduct campaigns, workshops, lectures, and exhibitions on sustainable practices for employees, with dissemination via intranet, posters, labels, and newsletters; produce information on socio-environmental topics, successful experiences, and progress achieved by the institution.
Purchases and Contracts	Prefer the acquisition of recycled or recyclable goods when possible; include the option of double-sided printing in reprography contracts; prefer the acquisition of recycled papers free of elemental chlorine or bleached with oxygen, hydrogen peroxide, and ozone; include in pantry and cleaning service contracts the adoption of procedures that promote rational use of resources and use recycled, reused, and biodegradable products; prioritize when possible, the use of local labor, materials, technologies, and raw materials; review cleaning contracts to rationalize based on the real dimension of the area under the contracted service; review internal norms and fixed and mobile telephony contracts to rationalize cost limits, device distribution, and personal use; review internal norms and security contracts to rationalize the real dimension of workstations; if possible, replace armed security with unarmed security in internal areas of the agency or entity; promote shared purchases.

Source: adapted from Normative Instruction No. 10/2012 (Brasil, 2012b)

Defining the research hypotheses

Lighting accounts for approximately 15% of global electricity consumption and about 5% of greenhouse gas emissions (World Bank, 2018). The World Bank (2018) estimates that, by 2030, the planet will generate about 259 billion tons of waste annually, and, by 2050, it will produce 340 billion tons annually worldwide if direct actions are not taken today. Meanwhile, the Global Conference on Prosperity through Water Services (2018) estimates that, by 2050, one in four people will live in a country with recurrent or chronic water shortages.

In this sense, the literature highlights that adopting sustainable practices can contribute to reducing solid waste and increasing the amount of recycled waste (Filimonau & Delysia, 2019; Barros et al., 2020; Hajar et al., 2020; Paiano, Crovella & Lagioia, 2020; Teixeira et al., 2020; Van Fan, Klemeš, Walmsley & Bertók, 2020; Zorpas, 2020) improving sustainable water management (Barros et al., 2020; Benson, Gain & Giupponi, 2020; Zorpas, 2020; Galimulina, Zaraychenko, Farrakhova & Misbakhova, 2020; Liu et al., 2021; Vanham & Mekonnen, 2021; Suo et al., 2021) and increasing efficient energy management to reduce consumption and increase renewable energy generation (Fonseca, Moura, Jorge & Almeida, 2018; Rebelatto, Salvia, Reginatto, Daneli & Brandli, 2019; Barros et al., 2020; Benson et al., 2020; Swain & Karimu, 2020; Zorpas, 2020; Chen, Sinha, Hu & Shah, 2020; Liu et al., 2021; Suo et al., 2021), among other effects.

Federal higher education public institutions are also committed to implementing sustainable actions. Even though they do not have industrial processes, they generate large amounts of waste, as well as water, paper and electricity consumption (Barros et al., 2020). The literature highlights the following practices: measuring carbon from the transportation of students and teachers (Barros et al., 2020), using bicycles or public transportation, using energy-efficient devices, efficient resource use, turning off lights in empty rooms, among other possible practices (Souza, 2020). Other actions were related to reducing water consumption (Barros et al., 2020), water treatment in universities (Geng, Liu, Xue & Fujita, 2013).

In Brazil, researchers Sudan and Zuin (2019) conducted a study at the University of São Paulo (USP) aimed at raising awareness among employees about environmental issues, integrating sustainability into university management, and promoting sustainable practices. Meanwhile, the Federal University of Bahia adopted practices to reduce water consumption in the institution—goal 6 of sustainable development. These actions began with daily water consumption monitoring, revealing leaks on campus that could be quickly fixed (Marinho, 2014). Thus, the results regarding water consumption reduction can be positive for organizations that effectively adopt the PLS to improve the sustainability of their operations.

Thus, the first hypothesis is proposed:

H1: Institutes that implement the Sustainable Logistics Program (PLS) reduce their water expenses compared to those that did not implement it.

Regarding energy variation through consumption reduction or energy production increases, Maistry and Annegarn (2016) highlight cost savings and resource efficiency as the main gains, mainly because global resource costs are increasing. Furthermore, Fonseca, Moura, Jorge, and Almeida (2018) and Rebelatto, Salvia, Reginatto, Daneli, and Brandli (2019) state in their studies that high energy consumption levels increase atmospheric pollutant emissions, affecting people's health and climate.

Regarding studies on reducing electricity consumption according to SDG 7 (affordable and clean energy) in federal higher education public institutions, the works of Rebelatto et al. (2019) at the Federal University of Passo Fundo (UPF) and Barros et al. (2020) at the Federal Technological University of Paraná (UTFPR) stand out. According to the authors, besides conducting awareness campaigns with students, teachers, and staff, the institutions replaced fluorescent lamps with LEDs that have higher energy efficiency and durability and installed photovoltaic panel systems for clean and renewable energy generation.

According to Rebelatto et al. (2019), replacing fluorescent lamps with LEDs resulted in a significant reduction in energy consumption, as fluorescent lamps consumed about 49,680 kWh/year, while the installed LEDs consume only 19,872 kWh/year. Additionally, the author highlights that constructing a Solar Photovoltaic Generation Park by UPF should generate 2,300 kWh/month. Thus, the results regarding energy consumption reduction can be positive for organizations that effectively adopt the PLS to

improve the sustainability of their operations.

Thus, the second hypothesis is proposed:

H2: Institutes that implement the Sustainable Logistics Program (PLS) reduce their energy expenses compared to those that did not implement it.

Regarding adopting sustainable practices that minimize waste generation, such as paper (SDG 12), Barros et al. (2020) highlight implementing an electronic information system to virtualize administrative processes (previously on paper), which resulted, for example, in the Federal Technological University of Paraná, in a 575% savings in printed paper in 2018. Thus, the results regarding paper consumption reduction can be positive for organizations that effectively adopt the PLS to improve the sustainability of their operations.

Thus, the third hypothesis is proposed:

H3: Institutes that implement the Sustainable Logistics Program (PLS) reduce their paper expenses compared to those that did not implement it.

Methodological elements of research

This research aimed to verify the relationship between implementing the Sustainable Logistics Plan (PLS) in the Federal Institutes of Education, Science, and Technology in Brazil (FIs) and the variation in expenses on energy, water, and office supplies of these Institutions from 2014 to 2019.

To achieve this study's objective, a quantitative and descriptive approach was employed with cross-sectional and secondary data collection. Concerning the estimation method, multiple linear regression analysis in a panel with fixed and random effects was used. This chapter describes the data and variables used to explain the research hypotheses. Subchapter 3.1 will present the econometric modeling to be used.

Population and sample

The sample consists of 36 Federal Institutes of Professional and Technological Education, considering data availability and the study was limited to the years 2014 to 2019. The financial data of the analyzed FIs were obtained through the government's Fala.Br database, the Brazilian Open Data Portal, and the Transparency Portal. To construct the PLS implementation variable, a manual search was conducted on the institutes' websites and official documents indicating PLS adoption and the year it was implemented. The explanatory variables were winsorized at 1% at the distribution tails.

Econometric model for hypothesis testing

The proposed model aims to analyze how PLS implementation impacts the percentage variation in energy, water, and office supplies expenses of the Brazilian Federal Institutes. To achieve this objective, equation (1) is proposed:

$$\Delta\%Desp_{it} = \beta_0 + \beta_1 PLS_{it} + \beta_2 lnMatricula_{it} + \beta_3 lnEquipamento_{it} + \beta_5 lnGastoMãodeObra_{it} + \beta_6 lnGastoObra_{it} + \beta_7 lnFuncionario_{it} + \varepsilon_{it} \quad (1)$$

Where $\Delta\%Desp_{it}$ refers to the annual percentage variation in energy, water, and paper expenses; PLS is a dummy variable that takes the value 1 in the year of PLS implementation and 0 otherwise; lnMatricula represents the natural logarithm of the number of students enrolled in the year; lnFuncionario is the natural logarithm of the number of institute staff; lnGastoMãodeObra, lnGastoObra, and lnEquipamento refer to the natural logarithm of expenditure on labor, campus works, and equipment, respectively.

For the hypothesis of this work not to be rejected, it is expected that the estimated coefficients of the interactions between the PLS implementation variable by the FIs and the implementation period variable are negative, i.e., $\beta_1 < 0$, indicating a decrease in the variation in expenses on energy, water, and sewage, or office supplies for the group of FIs that implemented the PLS.

As auxiliary exercises, the Hausman test was implemented to define the estimation via Fixed Effects or Random Effects, correlation analysis between variables, and mean difference test to identify if expense variation is different for FIs that implemented or did not implement the PLS. Finally, Table 1 below summarizes the variables used, calculation method, reference, and data source.

Figure 2 describes the variables used in this model.

Data Analysis

Descriptive statistics and variable correlation

Table 1 indicates the descriptive statistics results for the variables applied in the models. Firstly, the PLS variable has a mean of 0.08, indicating that 8% of observations have PLS adoption, considering only the implementation year. In the analyzed period, 20 Federal Institutes adopted the PLS at some point in the sample of 36 studied. For the variables of interest, which are the variations in energy, water, and office supplies expenses, there is a positive average variation, meaning that all these types of expenses are increasing on average for the analyzed sample. The smallest growth was in office supplies expenses, with a variation of approximately 10%, while water and energy expenses evolved by 17%. The highest expense variation was in office supplies, about 85 times the previous period's value, followed by a 27-fold increase in water and sewage expenses, and finally, the least significant increase was in energy expenses, with 108.

Figure 2
Description of variables

Variable	Type	Description	Source
Percentage variation in energy expenses	Explained	$\frac{DespEnergia_{it} - DespEnergia_{it-1}}{DespEnergia_{it-1}}$	Goldemberg e Lucon (2007)
Percentage variation in water and sewage expenses	Explained	$\frac{DespAgua_{it} - GastoAgua_{it-1}}{GastoEnergia_{it-1}}$	Lopes e Taques (2018)
Percentage variation in office supplies expenses	Explained	$\frac{DespMaterial_{it} - DespMaterial_{it-1}}{DespMaterial_{it-1}}$	Borges, Rosa, e Ensslin (2010)
PLS Implementation	Explained	*Dummy* that takes the value 1 for the year of PLS implementation, 0 otherwise.	Decreto nº 7.746 (2012)
Natural log of enrollments	Control	Natural logarithm of the number of student enrollments in federal institutions	Monteiro (2015)
Natural log of staff	Control	Natural logarithm of the number of staff in federal institutions	Souza (2014) Almeida (2015)
Natural log of labor expenses	Control	Natural logarithm of office labor expenses in federal institutions	Souza (2014) Almeida (2015)
Natural log of work expenses	Control	Natural logarithm of expansion work expenses in federal institutions	Souza (2014) Almeida (2015)
Natural log of equipment expenses	Control	Natural logarithm of equipment expenses in federal institutions	Souza (2014) Almeida (2015)

Source: prepared by the author

Table 1
Descriptive Statistics

Variáveis	Obs	media	sd	min	p25	p50	p75	max
pls	178	0,08	0,27	0,00	0,00	0,00	0,00	1,00
%var. material	178	0,10	0,80	-0,80	-0,25	-0,05	0,29	8,52
%var. energia	178	0,17	0,24	-0,42	0,02	0,11	0,24	1,08
%var. água	178	0,17	0,47	-0,95	-0,04	0,12	0,27	2,76
Ln(equipamento)	178	11,38	4,10	0,00	11,67	12,85	13,50	14,92
Ln(mão de obra)	178	12,36	4,76	0,00	13,64	14,20	14,57	15,27
Ln(gasto obra)	178	9,38	5,68	0,00	0,00	12,26	13,40	15,26
Ln(matrícula)	178	5,88	0,87	3,40	5,41	5,98	6,36	8,93
Ln(funcionário)	178	7,19	0,63	5,26	6,84	7,29	7,65	8,38

Note: pls indicates the PLS implementation dummy variable; %var. material refers to the annual variation in office supplies expenses; %var. energy refers to the annual variation in energy expenses; %var. water refers to the annual variation in water and sewage expenses; Ln(equipment) refers to the logarithm of equipment expenses; Ln(labor) indicates the natural logarithm of labor expenses; Ln(work expenses) indicates the natural logarithm of expansion work expenses; Ln(enrollment) refers to the natural logarithm of the number of student enrollments; Ln(staff) refers to the natural logarithm of the number of staff.

Source: prepared by the author

Table 2
Variable Correlation

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Pls (1)	1							
%var. material (2)	-0,01	1						
%var. energia (3)	0,03	-0,07	1					
%var. água (4)	0,03	-0,06	0,03	1				
Ln(equipamento) (5)	0,06	-0,05	0,03	-0,01	1			
Ln(mão de obra) (6)	0,06	-0,04	-0,02	-0,01	0,80***	1		
Ln(gasto obra) (7)	0,10	-0,10	0,17**	0,02	0,60***	0,50***	1	
Ln(matrícula) (8)	-0,04	-0,04	-0,01	-0,13*	0,20***	0,20**	0,20***	1
Ln(funcionário) (9)	-0,10	0,06	-0,19**	0,05	0,10	0,08	-0,10	-0,03

Note: pls indicates the PLS implementation dummy variable; %var. material refers to the annual variation in office supplies expenses; %var. energy refers to the annual variation in energy expenses; %var. water refers to the annual variation in water and sewage expenses; Ln(equipment) refers to the logarithm of equipment expenses; Ln(labor) indicates the natural logarithm of labor expenses; Ln(work expenses) indicates the natural logarithm of expansion work expenses; Ln(enrollment) refers to the natural logarithm of the number of student enrollments; Ln(staff) refers to the natural logarithm of the number of staff.

Source: prepared by the author. *** p<0.01 ** p<0.05 * p<0.1

Table 2 indicates the correlation between variables. Regarding the explained variables, it is noteworthy that there is no relationship between PLS and the chosen variables. In the correlation analysis, the reported results indicate a strong correlation between equipment expenses and labor expenses, which may present a multicollinearity problem for regression analysis. To identify the presence or absence of this problem, the variance inflation factor (VIF) statistics will be reported.

Table 3 below reports the results of the mean difference test. This analysis aims to identify whether the tested variables exhibit different mean behavior for the treatment and control groups, referring to FIs that implemented and did not implement the PLS, respectively. The reported results indicate no mean differences for the groups that implemented and did not implement the PLS in any of the analyzed variables.

Table 3
Mean Difference Test

	Group	**Obs**	**Mean**	**Difference**	**p-value**
%var. material	PLS = 0	163	0,10	0,03	0,89
	PLS = 1	15	0,07		
	Group	**Obs**	**Mean**	**Difference**	**p-value**
%var. energia	PLS = 0	163	0,17	0,03	0,65
	PLS = 1	15	0,20		
	Group	**Obs**	**Mean**	**Difference**	**p-value**
%var. água	PLS = 0	163	0,17	0,05	0,68
	PLS = 1	15	0,22		

Note: pls indicates the PLS implementation dummy variable; %var. material refers to the annual variation in office supplies expenses; %var. energy refers to the annual variation in energy expenses; %var. water refers to the annual variation in water and sewage expenses.

Source: prepared by the author. *** p<0.01 ** p<0.05 * p<0.1

Regression analysis

Table 4 reports the estimated coefficients for the proposed equation (1) and supporting statistics for analysis. In line with the correlation results presented in Table 2 and the mean test results presented in Table 3, the results indicate no relationship between PLS implementation and the percentage variation in energy, water, and office supplies expenses.

Therefore, the results indicate the rejection of H1, which supports that there is a decrease in the variation in water expenses by institutions that implement the PLS; the rejection of H2, which supports that there is a decrease in the variation in energy expenses by institutions that implement the PLS; and finally, the rejection of H3, which supports that there is a reduction in office supplies expenses by institutions that implement the PLS.

The debate on measures to be adopted for society to achieve higher sustainability levels is broad and globally considered (Nossa, Rodrigues & Nossa, 2017). The results reported in this work are relevant to the literature on adopting sustainability practices by the public sector in Brazil, especially by identifying the lack of practical results from PLS adoption in Federal Institutes, complementing the literature with qualitative case studies and descriptive approaches in Federal Institutes and Universities (Franco, Leite, Cameron, Lopes & Almeida, 2017; Nogueira, Moura-Leite & Lopes, 2018; Freitas & Rocha, 2017; Silva et al., 2018) and quantitative works such as Benites (2019), in which the author analyzes the PLS in Brazilian Federal Institutes of Education, Science, and Technology to understand how these institutions conduct their sustainability practices.

Table 4
Model Results

Variables	Energy Expense Variation	Material Expense Variation	Water Expense
pls	0,001	0,0068	0,044
	(0,02)	(0,045)	(0,36)
Ln(matrícula)	-0,04**	0,044	0,034
	(-2,20)	(0,94)	(1,40)
Ln(equipamento)	0,004	-0,0054	-0,003
	(0,47)	(-0,21)	(-0,20)
Ln(mão de obra)	-0,008	0,0054	-0,00065
	(-1,19)	(0,17)	(-0,052)
Ln(gasto obra)	0,0085***	-0,013	0,0069
	(3,73)	(-0,92)	(1,19)
Ln(funcionário)	-0,017	-0,021	-0,107
	(-0,98)	(-0,15)	(-1,45)
Constante	0,53***	0,11	0,72
	(2,75)	(0,10)	(1,38)
R^2-*within*	11%	1,1%	2%
pvalor Chi^2	0,0000***	0,655	0,17
Observações	178	178	178
pvalor Hausman	0,23	0,90	0,91
Tipo Estimação	Ef. Aleatório	Ef. Aleatório	Ef. Aleatório
VIF	2,59	2,59	2,59
Qtd de IF's	36	36	36

Model estimated:

$$\Delta\%Desp_{it} = \beta_0 + \beta_1 PLS_{it} + \beta_2 lnMatricula_{it} + \beta_3 lnEquipamento_{it} + \beta_5 lnGastoMãodeObra_{it} + \beta_6 lnGastoObra_{it} + \beta_7 lnFuncionario_{it} + \varepsilon_{it} \quad (1)$$

Note: pls indicates the PLS implementation dummy variable; %var. material refers to the annual variation in office supplies expenses; %var. energy refers to the annual variation in energy expenses; %var. water refers to the annual variation in water and sewage expenses; ln(equipment) refers to the logarithm of equipment expenses; ln(labor) indicates the natural logarithm of labor expenses; ln(work expenses) indicates the natural logarithm of expansion work expenses; ln(enrollment) refers to the natural logarithm of the number of student enrollments; ln(staff) refers to the natural logarithm of the number of staff.

Source: prepared by the author. *** p<0.01 ** p<0.05 * p<0.1

Discussion of results

The implementation of sustainable practices by higher education institutions is related to various UN Sustainable Development Goals (SDGs) because, besides generating resource savings, it also influences education and the dissemination of sustainable practices (Velada, Crespo & Rato, 2017; Nhamo & Mjimba, 2020). Table 5 reports the number of PLS adopters per year, and this adoption is growing, which is a positive result in the quest for sustainable development in the public sector.

However, despite the increased adoption over the years and the promotion of sustainable development discussions in higher education, a significant advance among the UN SDGs, the results indicate that, practically, steps still need to be taken for more effective implementation of sustainable practices with the PLS, as, from the three analyzed indicators, PLS implementation is not associated with their reduction. Therefore, the results of this work are important to support the recommendation that—beyond the discussion on the topic—higher education institutions need to focus more on the practical results of developed projects.

This work's scope is limited to analyzing energy, water, and sewage, and office supplies expenses of Federal Institutes. However, as pointed out by Nossa et al. (2017) and by the UN SDG guidelines, achieving sustainability requires acting in various dimensions.

Thus, future studies on the topic suggest expanding the research scope and period to allow more robust inferences. It is also recommended to replicate this research in other Brazilian public agencies to compare them and verify the PLS implementation compliance in these agencies.

Table 5
PLS Adoption

Year	No adoptions in the year	Adoptions in the year	% No adoptions in the year	% Adoptions in the year
2014	32	4	88,89%	11,11%
2015	33	3	91,66%	8,34%
2016	32	4	88,89%	11,11%
2017	32	4	88,89%	11,11%
2018	35	1	97,22%	2,78%
2019	32	4	88,89%	11,11%

Source: prepared by the author

Conclusions

This research aimed to verify the relationship between implementing the Sustainable Logistics Plan (PLS) in the Federal Institutes of Education, Science, and Technology in Brazil (FIs) and the variation in expenses on energy, water, and office supplies of these Institutions from 2014 to 2019.

The obtained results found that the variables of interest, water, energy, and office supplies, were not impacted by implementing the Sustainable Logistics Plan in the analyzed educational institutes. Based on this result, the hypotheses were rejected for not influencing PLS implementation, rejecting hypotheses 1, 2, and 3 of the research.

After analyzing and discussing the relationship between implementing the Sustainable Logistics Plan (PLS) in the Federal Institutes of Education, Science, and Technology in Brazil (FIs) and the variation in expenses on energy, water, and office supplies, it is evident that:

Empirical results showed no statistical significance in the tests after PLS adoption regarding the consumption indicators, considering the control factors. On the contrary, the interaction variable between PLS adoption and the analyzed period shows weak evidence of increased office supplies expenses. This indicates that the implementation process is facing difficulties in the FIs for various reasons outside this research's scope.

Therefore, there is a resistance to incorporating sustainable practices within the Federal Institutes of Education in Brazil, even with Decree 7,746/12 mandating the implementation of the Sustainable Logistics Plan for federal public agencies. Still, few Educational Institutes have adopted the program, evidencing the difficulty in preparing Information and Monitoring Reports for plans and actions, despite the law requiring it.

This research significantly contributes to

academic, social, and practical scenarios by examining interactions between sustainable practices and cost management in Federal Institutes in Brazil. Academically, it expands existing knowledge by linking sustainability actions to cost management with water, energy, and office supplies, providing empirical evidence enriching the literature. Socially, the study highlights the challenges and complexity of effectively implementing the Sustainable Logistics Plan (PLS), emphasizing the importance of well-adjusted public policies that respond to contemporary environmental demands. Practically, the insights offered serve as a guide for public managers in adapting and refining the PLS, promoting more efficient and environmentally responsible management. Thus, this analysis provides a critical platform for reassessing sustainable practices and inspires the creation of more robust strategies, contributing to a more integrated and conscious sustainable development in Federal Institutes and beyond.

One limitation of this research is the analyzed period from 2014 to 2019, as many FIs had not yet implemented the PLS. Additionally, it is noted that, during the studies, there was difficulty in receiving information from the representative sample, implying delays in data collection and, consequently, in results, limiting the research only to the Federal Institutes of Education, Science, and Technology in Brazil.

For future studies on the topic, it is suggested to apply the research scope and period to allow more robust inferences. It is also recommended to replicate this research in other Brazilian public agencies to compare them and verify the PLS implementation compliance in these agencies.

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