Public spending in the Brazilian Ministry of Education: an action research approach

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Abstract

Purpose

The innovation ecosystem makes it possible to build a network strategy that allows organizations to collaborate and evolve together, especially in public organizations in which the population's expectation for better services is growing and resources are scarce. Thus, the theory of the innovation ecosystem is analyzed in this study to structure mechanisms for spending efficiency within the institutions of the Brazilian federal education network. This choice is justified by the need to explore the coordination of the innovation ecosystem applied in the university context.

Design/methodology/approach

This study was carried out using a qualitative approach. An action research methodology was used on the Ministry of Education of Brazil (MEC), focusing on 110 institutions of the federal education network (federal universities and institutes). Action research was applied in this study because of its capacity to generate knowledge and address practical problems, specifically those concerning the efficiency of public spending in the examined educational institutions.

Findings

A model called the Innovation Ecosystem for Efficiency of Public Spending in Institutions of the Brazilian Federal Network of Education was developed. The model is composed of three layers: a core layer consisting of the MEC as a supervisory body that exerts influence over institutions, a platform layer consisting of four platforms, and a development and application layer consisting of actors that interact with ecosystem activities.

Originality/value

As its main contribution, this study presents how public institutions, especially those linked to the area of federal education, can organize and articulate partnership designs to promote innovation and efficiency in public spending.

Keywords: public spending efficiency, innovation ecosystem, public management, federal universities, federal institutes

1. Introduction

From the 1990s onwards, service efficiency became a central issue in public management (D'Inverno *et al.*, 2018; Titl and De Witte, 2021). Recent global economic crises and the constant need for governments to implement effective public policies at the lowest possible cost make it imperative that public spending be applied efficiently (Negri and Dincă, 2023; Yun, 2020). Therefore, states must reinvent and modernize themselves to boost their efficiency, which in turn enables them to execute their social functions more effectively (Negri and Dincă, 2023). The

efficient management of available resources is a topic of interest in public organizations and remains central to political and academic debates (D'Inverno *et al.*, 2018; Narbón-Perpiñá and De Witte, 2018; Negri and Dincă, 2023).

Approaches such as New Public Management have been proven incapable of facing new challenges and performing efficient management of public resources (Mariñez Navarro, 2022). Consequently, new alternatives are needed, and collaborative governance has become a fundamental requirement for improving the quality of government to face problems more efficiently and effectively (Mariñez Navarro, 2022; Zia ud din *et al.*, 2023). Thus, cooperation between public organizations can improve efficiency and reduce costs (Daymond *et al.*, 2023; Elston *et al.*, 2018). Collaborative solutions involve, among other things, staff sharing, shared purchasing, and systems development. Collaboration can be applied to improve the efficiency of common administrative activities or to achieve economies of scale and scope in support activities (Bovaird, 2014; Elston *et al.*, 2018).

In a world of increasingly specialized organizations, a single organization usually lacks the internal resources needed to develop and implement an innovation or a significant improvement in management (Talmar *et al.*, 2018). Thus, organizations need to count on the contributions of different actors—internal and external—to build a value proposition in the environment in which they are inserted (*ibid.*). In this context, the use of the ecosystem can be explored, as collaboration between two or more actors in an ecosystem results in a more significant overall benefit than can be achieved individually (Gomes *et al.*, 2023).

Organizations develop innovation ecosystems that empower them to tackle challenges characterized by high uncertainty and complexity (Adner, 2006; Nilsson and Ritzén, 2023). Nilsson and Ritzén (2023) proposes that the innovation ecosystem framework is particularly suited for collaborative efforts aimed at generating innovative solutions to significant challenges. Examining these efforts through the perspective of an innovation ecosystem offers valuable insights into the conception and coordination of these ecosystems.

The construction of an ecosystem has gained prominence in the strategy and practice of organizations (Su *et al.*, 2018). In management, an ecosystem refers to a network of interconnected organizations that are linked to or operate around an organization or technology platform and that produce valuable goods and services (Autio and Thomas, 2014; de Langen, 2023). An innovation ecosystem is considered a set of interconnected and interdependent organizations that compete and cooperate with each other in a dynamic structure that evolves and develops over time (Guo and Bouwman, 2016).

As for innovation ecosystem use, in recent years, its implementation has been identified in several areas aiming at network collaboration. Among these areas are technology (Rong, Hu, *et al.*, 2015), health (Pang *et al.*, 2015), cities (Roundy, 2017), services (Chen *et al.*, 2014; Guo and Bouwman, 2016), restaurants (Chesbrough *et al.*, 2014), electric vehicles (Lu *et al.*, 2014), social entrepreneurship (Surie, 2017), mobile internet (Jing, 2014), tourism companies (Perfetto and Vargas-Sánchez, 2018), three-dimensional printing (Rong *et al.*, 2018), family business (Habbershon, 2006), regional innovation ecosystems (Hu *et al.*, 2023), high-tech industries (Li *et al.*, 2023) and smart car industry (Wu and Negassi, 2023). These studies demonstrated the ability of the innovation ecosystem to act and collaborate in a network.

It is worth noting that no studies have been found that specifically use the innovation ecosystem to improve the efficiency of public management spending. Some articles are similar to the items proposed in this study, highlighting the work of Elston et al. (2018), who used a multidimensional conceptualization of interdependence derived from organizational theory to relate the complexity and forms of efficient collaboration to reduce expenses in the public sector. However, it does not describe what form of collaboration can be applied to maximize these gains, as proposed in this article.

Regarding universities, Villani and Lechner (2020) presented a case study of a young Italian university to explore the process of internal transformation to become entrepreneurial and fully inserted into its local innovation ecosystem. This study reported on the process of inserting a university into the local innovation ecosystem without addressing the structuring of the ecosystem to improve the institution's spending efficiency. To structure the innovation ecosystem, Su et al. (2018) used a new structure called the triple-layer core–periphery and suggested that the proposed structure could be used to build other innovation ecosystems.

Moreover, empirical research on innovation ecosystems for public management remains insignificant. Only a few researchers and research groups have examined the subject, as evidenced by the small number of studies published in scientific journals (Sant'Ana, Bermejo, *et al.*, 2020). In these studies, the role of the state in the innovation ecosystem is restricted to issues of regulation and standardization (Parente *et al.*, 2018; Rong, Wu, *et al.*, 2015; Su *et al.*, 2018; Surie, 2017), and no scientific work was found with public organizations as a central institution in the innovation ecosystem.

The concept of innovation ecosystem in the public sector is comprehensive and flexible, accommodating the critical elements necessary to investigate the phenomenon of public innovation (Carneiro *et al.*, 2023). Public sector organizations also need to collaborate among themselves and

with various stakeholders to co-create value through innovative processes (Nilsson and Ritzén, 2023). Public ecosystems should focus on encouraging connections to develop fruitful relationships, enabling the development of common or compatible goals, sharing resources, and participating in joint activities (Daymond *et al.*, 2023).

Thus, for the development of this study, we analyze the use of innovation ecosystem theory to structure mechanisms for the efficiency of expenditure within the institutions of the Brazilian federal education network, which is composed of federal universities and institutes. This choice of theory is justified by the gap in understanding that although the innovation ecosystem has been explored in companies, its application in universities remains scarce, especially considering the role that universities play in driving and coordinating the ecosystem and its application in university institutions (Grobbelaar, 2018). Despite efforts to integrate the ecosystem concept into public administration and management theory, discussions on the ecosystem approach remain quite abstract (Sahamies and Anttiroiko, 2024). Organizations are seeking new forms of cooperation and conditions to tackle major challenges, and the innovation ecosystem has the potential to formulate new cooperation strategies (Sulich and Soloducho-Pelc, 2024). In addition, the application of innovation ecosystems in public university institutions may have significant effects due to the complexity of managing these institutions, the constant criticism of low efficiency, and the similarity in their organizational structures.

Based on these findings, this study examines two important topics for the area of public administration. The first theme discusses the efficiency of public spending, which is essential for improving public policies. The second theme considers the application of the innovation ecosystem, with a few studies focusing on public management. Based on these considerations, the association of these two subjects can result in relevant contributions to public management, including subsidies, for the improvement of public policies.

Therefore, we seek to answer the following question: How do we develop an innovation ecosystem for the efficiency of expenditure within the institutions in the Brazilian federal education network (i.e., federal universities and institutes)? Moreover, given this problem, we assume that the development of an innovation ecosystem within federal universities and institutes contributes to strengthening the implementation of efficiency measures by these organizations. In response to the proposed question, this article presents the following main contributions: for organizational practice, the construction of an innovation ecosystem model aimed at spending efficiency in institutions of the Brazilian federal education network; and from a theoretical perspective, this study contributes by expanding the theories of Collaborative Governance and Governance Networks,

integrating the concept of innovation ecosystems with a triple structure (core, platform, and application), formalizing the role of central oversight, redefining the roles of actors, and introducing financial and qualitative efficiency metrics to evaluate collaboration.

This article is divided into six sections. Following the introduction in Section 1, Section 2 presents a review of the literature on innovation ecosystems, the efficiency of public spending and the projects identified and structured for spending efficiency in this research. Section 3 discusses the methodology and highlights the characterization, strategy, and procedures of the study. In the last three sections, the results, discussion, and conclusions are presented.

2. Literature review and project description

2.1 Innovation ecosystems

Moore (1993) first used the term business ecosystems and proposed that a company should not be seen in isolation but as part of an ecosystem, so that it develops cooperatively and competitively. The inspiration for the business ecosystem concept is taken from the biological ecosystem, in which each member within a business ecosystem, no matter how strong, ends up sharing its destiny with the entire group of members (Chen *et al.*, 2014, 2023; Iansiti and Levien, 2004).

In a natural ecosystem, species build an intimately interdependent community in which each species has a significant role that affects the evolution of other species (Helo *et al.*, 2021). According to these authors, the concept of business ecosystems has emerged in the information and communication technology industry. The term ecosystem has been used in a wide variety of contexts outside of its original application in biological systems (Autio and Thomas, 2014; Gomes *et al.*, 2018; Guo and Bouwman, 2016; Moore, 1993). In a business ecosystem, organizations co-evolve around innovation, working cooperatively and competitively to support innovative products and satisfy customer needs (Moore, 1993; Sulich and Soloducho-Pelc, 2024). Companies have different properties but share a common goal when dealing with uncertain business environments; this relationship makes it possible to create a more comprehensive view of collaboration (Helo *et al.*, 2021; Sulich and Soloducho-Pelc, 2024).

In the field of management, an ecosystem refers to a network of interconnected organizations that compete and cooperate with each other to produce valuable goods or services. They are linked to or operate around a central organization or technology platform (Autio and Thomas, 2014; Gomes *et al.*, 2023; Guo and Bouwman, 2016). Thus, a diverse group of actors

come together to create a unique value proposition, something that would be impossible to achieve individually (Nogueira *et al.*, 2023).

In this sense, the concept of the innovation ecosystem has gained space in the literature on strategy, innovation, and entrepreneurship (Gomes *et al.*, 2018), based on collective works to generate innovation (Wessner and Affairs, 2007). Its structure is composed of different stakeholders, including industrial actors, government, associations, suppliers, customers, and others who inhabit the same environment and co-evolve with each other, generating new values through innovation (Autio and Thomas, 2014; Ma *et al.*, 2018; Moore, 1993; Noble *et al.*, 2023; Su *et al.*, 2018). The main classifications concerning structuring an innovation ecosystem include life cycle, level, and layered structure (Sant'Ana, Bermejo, *et al.*, 2020). In addition to these items, Pucci et al. (2018) studied the role of actors in innovation ecosystems.

In the public sector, the innovation ecosystem engages in a variety of dimensions for the collaborative generation of innovations that bring benefits to society (Carneiro *et al.*, 2023; Sahamies and Anttiroiko, 2024). Carneiro et al. (2023) identified seven fundamental dimensions of innovation in the public sector that aim to represent a system that is multidimensional, interdependent, and complex. These dimensions are the actors involved in the ecosystem; the nature or function of these actors within the ecosystem; the skills and preferences of these different actors; the operations, functions, and technologies associated with public innovation mechanisms; the nature of the innovation itself; and the creation of public value resulting from innovation. Public ecosystem architects have the ability to launch and manage projects and programs that encourage the formation of new connections at multiple levels (Daymond *et al.*, 2023).

A central feature of ecosystems is coevolution, which refers to how actors, roles, activities, artifacts, and organizations co-evolve over time (Gomes *et al.*, 2023). De Langen (2023) highlighted the role of the ecosystem developer and considered this central actor a distinctive feature of an ecosystem compared with concepts related to clusters or networks . The central actor simplifies the task of connecting participants to each other, thus increasing productivity and improving efficiency (de Langen, 2023; Pouru-Mikkola *et al.*, 2023). Finally, the central actor needs to create conditions for the continuous cooperation of the participants, expanding connections and intensifying them (Daymond *et al.*, 2023; Falcke *et al.*, 2023).

Public sector organizations need to establish mutual collaborations with diverse stakeholders to co-create value through joint innovation processes (Nilsson and Ritzén, 2023). According to Nilsson and Ritzen (2023), the innovation ecosystem in the public sector must be structured to facilitate collaborative efforts between government authorities, aiming to create innovative solutions to major challenges. Analyzing these efforts from the perspective of an innovation

ecosystem can provide valuable insights into how these ecosystems can be designed and coordinated (Nilsson and Ritzén, 2023).

2.2 Efficiency of public expenditures

Budgetary and macroeconomic constraints in several countries have made discussions on the efficiency of public spending a relevant topic in political and economic debate (Afonso *et al.*, 2010). The efficiency of public spending is related to the government's ability to maximize its economic activities, given the level of spending, or the government's ability to minimize its spending, given the level of economic activity (Chan and Karim, 2012).

The concept of efficiency describes how productively mobilized resources are transformed into the desired result (Cepparulo and Mourre, 2024). Considering the relationship between inputs (human resources, technical resources, material resources, or financial resources) and outputs (goods and/or services) is the most interesting way to study efficiency (Araujo Neto *et al.*, 2023). In the public sector, the variables most widely used in the literature are input (financial expenses, financial resources, and non-financial inputs) and output (production indicators, total population, built area, administrative services, infrastructure, health, education, social services, public security, public transport, and environmental protection) (Narbón-Perpiñá and De Witte, 2018).

Measuring the efficiency performance of public sector organizations is noticeably more difficult than that of private organizations, as public sector organizations produce goods that are provided free of charge or at a price that is not determined by market forces (Manzoor, 2014). Deficient budget classifications, lack of data, difficulties in attributing fixed costs, and not attributing any value to the use of public goods used in the activity make it difficult to determine the real costs (Afonso *et al.*, 2010). To achieve efficiency in public management, it is essential to adopt methods that allow for the evaluation of budgets and public expenditures based on their performance (Yachachin Villanueva, 2023).

In this sense, organizations have sought innovative ways of acting, especially since the administrative reforms of the 1990s, in the wake of New Public Management, aiming especially to improve their performance and reduce their costs (Damanpour *et al.*, 2009; Hansson *et al.*, 2014). Recent studies have indicated that approaches such as New Public Management have proven incapable of facing new challenges and require the implementation of new alternatives (Mariñez Navarro, 2022). In this context, collaborative participation is essential to improve the quality of government because it promotes values such as innovation, transparency, and participation (*ibid.*). In addition, during the COVID-19 crisis (2020–2021), government priorities were readjusted to

support digital transformations, with the aim of improving the effectiveness of public administration and ensuring the sustainability of public finances (Kotina *et al.*, 2022).

In the field of governance, some studies have pointed out that collaboration between independent public bodies and the sharing of services has been used to reduce costs, especially with gains in scale and efficiency (Elston *et al.*, 2018; Mostofi *et al.*, 2023; Tomasino *et al.*, 2017). Collaboration increases problem-solving ability and achieves efficiency and effectiveness (Mills *et al.*, 2021). Collaborative organizational arrangements are positively related to efficiency (Kajamaa and Hurmelinna-Laukkanen, 2022). They enable the collaboration of various resources, perspectives, and types of knowledge, which results in the development and implementation of initiatives aimed at solving complex problems (Barrutia *et al.*, 2022).

In the public sector, cooperation between organizations is not primarily motivated by saving transaction costs or jointly producing a good or service to gain a competitive advantage. On the contrary, the main objective is to solve larger-scale public problems (Siciliano and Whetsell, 2023). Collaborative participation is seen as an interactive process that promotes collective learning, the exchange of knowledge, and the sharing of responsibilities in implementing objectives (Mariñez Navarro, 2022). Intergovernmental collaboration can bring great benefits to the public community (Figenschou *et al.*, 2024).

Collaboration between organizations can be applied to improve the efficiency of common administrative activities or to achieve economies of scale in support activities (Elston *et al.*, 2018). Given that the Brazilian federal education network is composed of 110 institutions that have similar administrative and support activities, this study proposes the use of cooperation mechanisms based on the innovation ecosystem to improve the efficiency of spending at federal universities and institutes. Future research should assess the efficiency and cost-reduction effects of administrative innovations in procurement, human resources, and technology in the public sector (Sant'Ana, Lopes, *et al.*, 2020).

2.3 Projects identified and structured for spending efficiency in this article

The services or products of the innovation ecosystem were structured in the form of projects and prioritized in conjunction with the Ministry of Education, considering those that could generate faster results with less effort. Sixteen projects were structured to improve spending efficiency in institutions, with nine new projects developed from the innovation ecosystem structure and seven existing projects incorporated into the ecosystem and made available to all institutions. The projects

were organized into four groups (quadrants): support projects that generate management improvements, management projects based on technology, technology projects that generate innovative processes, and innovation projects that create support structures.

The projects structured in the first group aim to support structures that allow for improved management. These include: strategic planning, process mapping, system process modeling, and cost indicators. In the second group, projects related to management that use technological processes to enhance institutional activities are developed. The projects in the second group are: coronavirus panel (used to monitor the functioning and support the actions of institutions during the coronavirus response), 360º University panel (a higher education observatory aimed at developing solutions for the analytical management of academic indicators, budget execution, and personnel development), Plataforma For (aims to provide a cloud platform to support institutional development plans and risk management for institutions), and ICPEdu (aims to enable digital signatures for managers, teachers, staff, researchers, and students).

In the third group are projects with characteristics of technological products or services that can generate innovations and improve the activities of institutions, fostering the achievement of objectives. These include: MECintheClouds (a digital transformation program aimed at accelerating the provision of digital services and solutions), EMBRAPII units (aimed at fostering research, development, and innovation projects within institutions), Reuni Digital (envisioned to expand access and retention of students in public higher education through distance education), and EnergIFE (a program for the development of renewable energy and energy efficiency).

In the last group are structured projects that promote a significant breakthrough or improvement in previously established methods through a new proposal for the development of a product or service for institutions in the Brazilian federal education network. The projects developed or underway in this group are: Digital Diploma (an innovation in the academic field that will enable the modernization of the procedural flow for diploma issuance and registration), Eduplay (a university platform for audiovisual content for education and research), Integrated Academic Success Support System - SISSA (a platform based on artificial intelligence that combines academic data integration, student success prediction, and peer interactions in a system that supports the student, together with the educational institution, in building a successful course trajectory), and Connected Students (providing and monitoring internet data packages for students in socioeconomic vulnerability).

3. Methodology

3.1. Research characterization and strategy

This study used the concept of an innovation ecosystem to develop a cooperation mechanism aimed at improving the efficiency of public spending. For this, it was necessary to identify a set of institutions that had the characteristics of networking, the need to improve efficiency, data availability, and above all, the possibility of articulation through a central organization. In view of these characteristics, the institutions of the Brazilian federal education network (110 in total) were selected for this study. The central body was the Ministry of Education (MEC), which is responsible for strengthening collaborative action between these institutions. The factors that motivated the choice of these institutions were the complexity of management, the constant criticism of low efficiency, and the similarity in their organizational structures (Pessoa, 2000).

This study adopted a qualitative approach because it allows for the necessary depth in studying and applying the innovation ecosystem to foster cooperation among the institutions comprising the Brazilian federal education network for improved efficiency. An action research strategy was used to develop this study.

Action research is a type of social investigation associated with an action or the resolution of a collective problem and is based on the cooperation and participation of researchers and individuals or groups representative of the situation or problem (Thiollent, 2011). According to Coughlan and Coghlan (2002), four characteristics define action research: (1) research in action rather than research about action, (2) participatory, (3) concurrent with the action, and (4) a sequence of events and a problem-solving approach. Moreover, the authors showed that action research is appropriate when the research question pertains to the description of a series of actions that unfold over time within a given group, community, or organization.

Action research has enabled us to conceive and organize social research with a practical purpose, in which research and action must be developed jointly with the participation of the actors in the observed situation (Thiollent, 2011). In this context, action research serves as a research strategy for generating knowledge and solving practical problems (Mello *et al.*, 2011). One of the unique aspects of action research is the relationship between these two types of objectives: (1) practical objectives, which aim to contribute to the resolution of a problem through the survey of solutions and proposal of actions, and (2) knowledge objectives, which aim to obtain information that would be challenging to acquire through other procedures (Thiollent, 2011).

Therefore, in this study, action research was applied to expand knowledge and improve efficiency in public spending in institutions of the Brazilian federal education network using the construct of the innovation ecosystem within the scope of the MEC, the body responsible for supervising these institutions.

3.2. Research procedures

Following Mello et al. (2011), the content proposal and action research sequence were organized into five phases: (1) plan, (2) collect data, (3) analyze data and plan actions, (4) implement actions, and (5) evaluate results and generate reports. Table 1 presents the phases and describes each step and its method of execution.

[Table1]

As shown in Table 1, the first phase consists of planning the action research in three steps: definition of the conceptual–theoretical framework (theoretical framework), selection of the unit of analysis and data collection techniques, and definition of the context and purpose of the research (Mello *et al.*, 2011). For the data collection phase (second phase), the sources used for data collection included document analysis and participant observation. In addition to participant observation, weekly meetings were held between the researcher and the participants to record the data during the development of the study.

Data analysis (third phase) was conducted collaboratively with the Project Management Unit, the Projects and Processes Office, the Board of Development of the Network of Federal Institutions of Higher Education, and the Board of Development of Professional, Scientific and Technological Education Network. This was coordinated by the researcher.

4. Results

This section presents the data on the implementation of the plan and an analysis of the results of the application of the innovation ecosystem within the scope of the MEC of Brazil. An innovation ecosystem model (Section 4.1) and its application (Section 4.2) are presented. The MEC is an organ of the direct federal public administration of Brazil responsible for national education policy at all levels. The Brazilian federal education network is composed of 69 institutions of the federal higher education network (federal universities), which are supervised by the Higher Education Secretariat (SESu), and 41 institutions of the federal network of professional, scientific,

and technological education (federal institutes), which are supervised by the Secretariat of Vocational and Technological Education (SETEC).

4.1. Proposal of an innovation ecosystem model and its application in the institutions of the Brazilian federal education network

Collaboration and cooperation between organizations are seen as a way to achieve enhanced capabilities focused primarily on value creation, so an organization's performance and competitiveness do not depend only on its own capabilities but also on the capabilities that the organization can access through its innovation ecosystem (Sandhu *et al.*, 2019). Due to the significant role universities are acquiring in the development of regional economies, they are facing considerable pressure to become more entrepreneurial and similar to private sector organizations (Villani and Lechner, 2020).

Therefore, considering the SESu and SETEC of the MEC as the bodies responsible for strengthening collaborative action between the institutions of the Brazilian federal network of education, a model of an innovation ecosystem is proposed for spending efficiency in federal universities and institutes. The proposed model applies the basic concepts of business management and innovation management to promote and strengthen efficiency.

The proposed model (Figure 1) is based on the triple-layer core–periphery structure developed by Su et al. (2018) for the Sigma Group innovation ecosystem in China, and the framework can be used to study other innovation ecosystems.

[Figure1]

As shown in Figure 1, the innovation ecosystem model for spending efficiency in the institutions of the Brazilian federal education network is composed of three layers: core, platform, and development and application. The core layer represents the MEC as the supervisory body that exerts influence over institutions. The platform layer is provided by the central organization in which the cooperation actually takes place. Thus, four platforms were defined with a view to cooperating and improving spending efficiency: support, management, technology, and innovation. The development and application layer consists of actors that have close relationships with activities in addition to federal universities and institutes, research laboratories, social organizations, and control agencies. The details of each layer, its function, and the actors involved are presented below.

4.1.1. Core layer

The core layer consists of one or more organizations that exert strong influence and act as regulators and coordinators of the innovation ecosystem in addition to building the platform layer. The platform layer connects the core layer and the development and application layer (Su *et al.*, 2018). As shown in Figure 1, at the core of the innovation ecosystem is the MEC, which acts as the central organization. It is responsible for strengthening the collaborative actions of the institutions that make up the Brazilian federal education network. Under the MEC, the SESu and SETEC are responsible for orchestrating and leading the development of the innovation ecosystem.

The function of the core layer is to guide all ecosystem members to innovate around a shared long-term objective and future, leading to the optimization and sharing of resources and improvements in efficiency (Su *et al.*, 2018). However, in the MEC, there was no mechanism for integration and collaboration between the institutions, much less for joint action between the 110 institutions. Thus, from the construction of this innovation ecosystem, it was possible to structure a process for collaboration between federal universities and institutes.

The relationship between the core layer and the platform layer is one of control and use, in which the central organization must provide, improve, control, and be a user of the platforms, sharing resources and cooperating with each of them (Su *et al.*, 2018).

4.1.2. Platform layer

The central organization must build platforms with different functions (platform layer) that connect different peripheral actors (Su *et al.*, 2018). These platforms have intense interactions and collaborations, stimulating the growth of the innovation ecosystem (*ibid.*). In preparing the proposal, as shown in Figure 1, the institutional strategic planning of the MEC was considered. In its value chain structure, the document presents the organization of its institutional macro-processes from three perspectives: support, governance, and finalistic macro-processes.

Thus, considering the macro-process structure, the support platforms (support macro-processes), management (governance macro-processes), technology, and innovation (finalistic macro-processes) were defined. On the support platform, projects are structured to support stakeholders' management activities because they promote coordination actions for innovation. The management platform includes projects aimed at optimizing the management of activities in organizations based, above all, on achieving the mission and objectives of the innovation ecosystem. The technology platform aims to develop incremental action in technological products and services to improve organizational activities and promote the achievement of objectives.

Finally, the innovation platform promotes a rupture or a significant change in previously established methods through a new product or service proposal for the development of an activity.

The platform layer works as a connector between the central organization and the actors from the development and application layer. This is where cooperation takes place (Su *et al.*, 2018).

4.1.3. Development and application layer

The development and application layer consists of actors that have close relationships with the activities of the innovation ecosystem, such as partner organizations, financial institutions, research institutes, universities, and clients, which are considered the peripheral actors in the core–periphery structure (Su *et al.*, 2018). Actors participate in activities/projects/services through platforms with highly specialized knowledge, skills, products, and services to achieve the objectives of the entire ecosystem (*ibid.*).

In the proposed model, the main actors of the development and application layer are the 110 institutions of the Brazilian federal education network, the research and development laboratories of federal universities and institutes, social organizations, and internal and external control agencies. The other actors that interact with the innovation ecosystem are the other executive and legislative bodies, the private sector, and the managers, professors, technicians, and students from these institutions.

The institutions of the Brazilian federal education network contribute to the development of this layer, as they are the institutions that benefit from the results of the innovation ecosystem, both quantitatively and qualitatively, through the implementation of projects and processes that improve management and the application of resources that generate gains in scale, thus improving efficiency. The research and development laboratories at federal universities and institutes are responsible for building innovative projects and processes that allow their improvement.

4.2. Results of the application of the innovation ecosystem for the efficiency of the institutions of the Brazilian federal education network

From the elaboration of the innovation ecosystem for the efficiency of expenditure in the Brazilian federal education network, its application was carried out to verify the research results. This application took place through its institution in the MEC and, consequently, in the organization and execution of projects to contribute directly or indirectly to the improvement of public spending efficiency.

Thus, to organize the platforms, projects were identified and structured for spending efficiency in institutions according to the classification defined in the ecosystem model: support, management, technology, and innovation. In defining the projects, priority was given to those already under development in the secretariats, new projects that could generate a greater impact with less effort, and projects that were requested or identified as necessary by the institutions. The projects were organized into quadrants to structure the innovation ecosystem, as shown in Figure 2.

[Figure2]

In addition to identifying the layers (core, platform, and development and application) according to the model proposed by Su et al. (2018), which is based on the triple-layer core-periphery structure, an improvement was implemented by structuring four quadrants to consolidate the projects (Figure 2). This structuring was performed because it was identified that the support projects generated improvements for management (Q1), the management projects were based on technology (Q2), the technology projects generated innovative processes (Q3), and the innovation projects created structures that supported the institutions' activities (Q4). This application confirms the feasibility of using the proposed model proposed by Su et al. (2018) to study another innovation ecosystem. The structuring of the quadrants reinforces that the platforms have different characteristics; however, they can overlap in some of their functions, interacting in practical operations. Thus, different platforms can contribute to different stages of innovation and collaborate towards a common goal.

The projects in Q1 (support/management) aim to establish support structures that allow for improved management because they foster ecosystem coordination (e.g., strategic planning, process mapping, systems modelling, and the construction of indicators). The projects in Q2 (management/technology) are related to management and utilize a technological process to enhance the activities of institutions. The projects in Q3 (technology/innovation) possess the characteristics of technological products or services, which can generate innovations and improve the institutions' activities, thereby promoting the achievement of objectives. The projects in Q4 (innovation/support) develop new products or services that promote significant advancements for institutions.

Efficiency was measured in terms of time, financial savings, and qualitative criteria. After the establishment of the innovation ecosystem within the Ministry of Education, the projects were structured and organized with the aim of improving public spending efficiency. For project management, the 5W2H methodology was used, a framework that serves to monitor and verify the

activities, deadlines, and responsibilities of all involved. Thus, for each implemented project, it was possible to measure efficiency gains, especially regarding the availability of tools for all institutions, reducing local installation and configuration costs. For new projects, the benefits and impacts were proposed based on the study conducted for the creation of each one.

Table 2 presents the main benefits/qualitative impacts of innovation ecosystem projects to improve spending efficiency in federal universities and institutes. There were 16 projects, nine of which were new projects, created with the concept of an innovation ecosystem, seeking to meet the demands of the secretariats and improve spending efficiency in the institutions of the Brazilian federal education network. The seven other existing projects were incorporated and expanded to serve all institutions, as their scope was restricted to only one group of institutions.

Plataform For and Digital Diploma were developed in isolation by a few institutions, leading to the duplication of costs, limited use, and difficulties in implementation. Eduplay, ICPEdu, and MECintheClouds, which were under the development of the National Education and Research Network, were identified and replicated within the innovation ecosystem. EnergIFE was developed only by institutions in the federal professional education network and was incorporated into the ecosystem, thereby also covering the institutions in the federal higher education network. The EMBRAPII units were expanded to serve institutions with the potential to structure new units or innovation hubs.

[Table2]

Considering the data in Table 2, in each project comprising the innovation ecosystem, it is possible to envision the potential of this tool to improve the spending efficiency in the institutions of the Brazilian federal education network. Table 3 presents the main projects developed, the website, the main objective, and the most outstanding result/improved efficiency.

[Table3]

In addition to the qualitative benefits/impacts demonstrated above, it is also important to highlight the quantitative efficiency gains in the projects. In general, all projects had avoided costs for each institution and, consequently, the gain in scale of their availability to all institutions. Of the

16 projects, eight have a direct effect on improving institutional spending. In four of them, it is possible to calculate the savings generated thus far, which are approximately $21 million (Table 4). The total expected value of spending in each project is calculated considering the implementation without using the ecosystem and the actual amount spent to arrive at the result of the savings generated. It should be noted that the savings provided will be even greater when all institutions join the projects, especially the Plataform For, Digital Diploma, and ICPEdu projects.

[Table4]

The Connected Students project served 111,697 students in the last 12 months, and the savings generated in one year was approximately $18,085,804.73 (considering the average price of the 20 GB Internet chip in 2021 at $15.53 and the ecosystem value of $2.04 per chip). For ICPEdu, the implementation cost was approximately $194,174.76, enabling issuance for students and staff of all institutions. By the end of 2021, 71,000 certificates were issued, generating savings of $483,500.00. Fifteen institutions signed up to use PlataformaFor, with an implementation cost of $229,191.09. It is estimated that the cost for each institution would be $59,964.13 with local system implementation, thus, the savings generated to date is $670,270.86. In the Digital Diploma project, ninety institutions signed up for use, with an implementation cost of $279,611.65, and the savings generated was $1,904,854.37, considering that each institution would spend an average of $24,271.84 to develop the system individually.

5. Discussion

The development of an innovation ecosystem in the MEC of Brazil, specifically the institutions of the Brazilian federal education network, is based on the gap identified in the article, “Developing a local innovation ecosystem through a university coordinated innovation platform: The University of Fort Hare.” Although the role of innovation platforms in the concentration and coordination of an innovation ecosystem has been explored in the business context, their application in the university context remains poorly explored (Grobbelaar, 2018). Based on this gap and the triple-layer core–periphery structure (Su *et al.*, 2018), the innovation ecosystem for spending efficiency in federal universities and institutes was built.

Collaboration between public sector organizations is generally understood as a response to complexity, and organizations seek to collaborate to address complex and cross-cutting needs that

cannot be met individually (Elston *et al.*, 2018). Thus, organizations need to rely on the contributions of different actors, both internal and external, to the institution to build a value proposition in the environment in which it is inserted (Talmar *et al.*, 2018). As Daymont et al. (2023) pointed out, cooperation between organizations can improve efficiency, with results in the short, medium, and long term.

Despite extensive research on collaboration in the public sector, these interactions are rarely framed in terms of ecosystems (Nilsson and Ritzén, 2023). Instead, concepts such as interagency collaboration, collaborative governance, or collaborative innovation are frequently applied (*ibid.*). Nilsson and Ritzén (2023) proposes that the innovation ecosystem is particularly applicable to collaborative efforts among government authorities aimed at creating innovative solutions for major challenges. Sulich and Soloducho-Pelc (2024) supports this proposal, highlighting that the ecosystem concept has the potential to formulate new cooperation strategies. The definition of innovation ecosystems is highly relevant to collaborative efforts among government authorities, enabling public sector organizations to collaborate with each other and with various stakeholders to co-create value (Nilsson and Ritzén, 2023).

In this context, an innovation ecosystem was developed to create a cooperation mechanism for the efficiency of institutions of the Brazilian federal education network using the following elements in its composition: (1) the four-phase life cycle model (birth, expansion, leadership, and self-renewal) (Letaifa, 2014; Moore, 1993); (2) the level of national scope as it involves institutions from all Brazilian states (Pombo-Juárez *et al.*, 2017; Su *et al.*, 2018); and (3) the triple-layer core–periphery structure (Su *et al.*, 2018) due to the supervision characteristics of the secretariats, the structuring of the projects, and the different actors that make up the ecosystem.

The creation of an innovation ecosystem requires the establishment of structures and strategies throughout the so-called ecosystem life cycle, established in four stages: birth, expansion, leadership, and self-renewal (Moore, 1993). The innovation ecosystem developed in this study is currently advancing in the leadership phase. The ecosystem is mature and focuses more on capturing value, which means something beyond the expected economic gains, leveraging organizations' opportunities and creativity for the development of new projects (Letaifa, 2014). There is a need for true leadership in the ecosystem to help organizations communicate better and take advantage of collaborative capabilities, as the ecosystem developer can increase productivity and simplify the task of connecting participants (de Langen, 2023).

As for the level, the innovation ecosystem has a nationwide scope, as these 110 institutions are present in all Brazilian states. Ecosystems can also evolve from one level to another (Chesbrough *et al.*, 2014). The ability to expand or update the ecosystem has three sub-dimensions

for scalability: input scalability, geographic scalability, and administration scalability (Pombo-Juárez *et al.*, 2017). Thus, in the future, regional structures can be created to deal with the demands specific to each region.

In developing the innovation ecosystem within the scope of this article (i.e., for spending efficiency in the institutions of the Brazilian federal education network), the triple-layer core–periphery structure (Su et al., 2018) was used. The proposed structure proved to be effective in the construction of the ecosystem, mainly due to the relationship between the actors. Ecosystem thinking offers public organizations a holistic view to understand the system's dynamics, mobilizing actors and resources in the collaborative creation and implementation of public, social, and service innovations that generate public value (Sahamies and Anttiroiko, 2024). Organizations must engage in continuous collaboration to respond interactively and quickly to changes in their environment (Sulich and Soloducho-Pelc, 2024). Ecosystems are generally supported by modular structures, called platforms, which facilitate interactions among actors, allowing them to interact, integrate resources, participate in an orderly manner, and innovate (Osorno-Hinojosa *et al.*, 2023). Information sharing and knowledge management are essential factors in ecosystems. Therefore, platforms must have elements that ensure interoperability and integrity (*ibid.*).

The secretariats (SESu and SETEC) are the providers, controllers, and users of the platform, sharing resources and cooperating through support, management, technology, and innovation structures. The relationship between the central layer and the platform layer is one of control and utilization (Su *et al.*, 2018); this occurs when cooperation takes place, creating a connector between the secretariats and the universities, institutes, and other organizations that make up the ecosystem. According to Su et al. (2018), the platform layer must be provided by the organizations that make up the core of the ecosystem. The relationship between the development and application layer and the platform layer is one of utilization and development; organizations use resources to support their activities and add value to the platform, providing new services and products (Su *et al.*, 2018). Thus, the 110 institutions in the development and application layer can develop or assist in the development of new services and products for use throughout the network.

The innovation ecosystem has real implications for the practice of organizations. Collaboration between organizations improves their capabilities and allows for efficiency gains. Collaboration between two or more actors in an ecosystem results in a more significant benefit for all than what can be achieved individually (Gomes *et al.*, 2023). Innovation ecosystems are built on systemic principles. In this way, they establish effective implications for managerial practice, especially for policy development and analysis (Suseno and Standing, 2018). Collaboration and cooperation between organizations are increasingly seen as ways to achieve enhanced capabilities

centered on innovations and greater value creation (Sandhu *et al.*, 2019). The performance and competitiveness of a company or project do not rely only on its own capabilities and activities but on the capabilities that the organization can access through its innovation ecosystem (*ibid.*).

Aldag et al. (2020) pointed out that the spending efficiency caused by the cooperation between organizations depends on the characteristics of each service, as the sharing of services can result in higher expenses due to the associated administrative costs. The efficiency of expenditure, as proposed in this study, can be achieved, considering that a large part of the administrative cost is already present in the supervision function of the MEC. In addition, for each service to be shared, the cost of implementation and the cost efficiency generated can be verified. Another aspect addressed by Aldag et al. (2020) is related to service quality because even if there is no effective gain in expenses, according to the authors, there can be an improvement in the quality of the service offered. In the projects implemented within the scope of this article, it was possible to perceive gains in the efficiency of expenditure and the improvement of the quality of services.

Significant advances have been observed in the practice of institutions in the federal education network. Among the main ones, the following stand out: increased transparency in the data and actions of the departments, optimization and improvement of secretariat processes, more efficient use of public resources, gain of scale in project implementation, improvement in the management of developed projects, cost reduction in making projects available nationwide, greater availability and better functioning of the services included in the ecosystem, and greater involvement of institutions in solving problems, resulting in improved efficiency. However, from a practical point of view, the greatest difficulty lies in the adherence of all institutions to the new processes and projects developed, which could result in even more significant effects on the developed ecosystem.

Finally, because of this major role universities play in the development of economies, they face significant pressure to become more entrepreneurial and more similar to private-sector organizations. This new role requires universities to engage in substantial change activities to gain legitimacy from their ecosystems (Villani and Lechner, 2020). Let us consider the role of federal universities and institutes in Brazil, and that these institutions are facing significant pressure to adapt to substantial changes in the external environment, especially due to budget reductions imposed in recent years. In this context, the results of this study can help improve the spending efficiency of these institutions and, consequently, their adaptation to the new challenges imposed.

6. Conclusion

The general objective of this study was to develop an innovation ecosystem to improve public spending efficiency in public education institutions. To achieve this goal, innovation ecosystem theory was used, which made it possible to build a network strategy that allows organizations to collaborate and evolve together, especially in public organizations in which the population's expectation for better public services is growing and resources are scarce. The locus of study was the MEC of Brazil, specifically the federal universities and institutes, which is justified by the constant criticism of its efficiency in executing its budgets, the pressures to improve management, and the budget reductions imposed in the last few years.

The theoretical model developed in this study is composed of three layers: core, platform, and development and application. To apply the model, 16 projects were structured. Of these projects, nine were new projects that were developed based on the structure of the innovation ecosystem, and seven were existing projects that were incorporated into the ecosystem and made available to all institutions. With the implementation and results of each project that makes up the innovation ecosystem, it was possible to envision the model's potential for improving the efficiency of spending in the institutions. In addition to the qualitative benefits/impacts, it was also possible to quantify the quantitative efficiency gains in four projects already implemented, which was approximately $21 million.

6.1 Theoretical and practical contributions

From a theoretical perspective, the main contributions of this study are as follows: (1) it contributes to innovation ecosystem theory and explores the characteristics influencing the structure of the ecosystem, its challenges, and its trends; and (2) it develops an innovation ecosystem model for spending efficiency in institutions of the Brazilian federal education network. From a practical perspective, the main contribution is that it presents how public institutions, especially those linked to the federal education area, can organize themselves and articulate partnership designs to promote collaboration and spending efficiency.

The article also contributes to the theories of Collaborative Governance by integrating the concept of innovation ecosystems, introducing a triple structure (core, platform, and application) that operationalizes collaboration at complex levels of public governance. It formalizes the role of a central body, such as the Ministry of Education, challenging the assumption of exclusive horizontality and suggesting that central oversight can facilitate collaboration without compromising local autonomy.

Regarding Governance Networks, the article demonstrates that they can achieve national scale and modularity, connecting multiple institutions and allowing for geographical and administrative scalability. Additionally, it redefines the roles of actors in distinct layers (core, platform, and application), detailing how these roles can co-evolve to meet specific demands. Finally, both theories are expanded by incorporating efficiency metrics and measurable outcomes, such as financial gains and process optimization, creating a new paradigm for evaluating the results of collaboration in public ecosystems.

6.2 Research limitations

This study has some limitations. First, the innovation ecosystem is restricted to the MEC and the institutions of the Brazilian federal education network. This limitation is related to the MEC's competence in supervising these institutions, which does not occur in private institutions or other spheres (state and municipal). Second, only qualitative research was used, and the quantitative analysis of the results was not within the scope of this study. Third, the proposed projects were restricted to those identified and prioritized under the perception of the high-level managers at the MEC.

6.3 Suggestions for future studies

The following proposals for future research are suggested: (1) Longitudinal studies: Research that analyzes the formation, implementation, and evolution of innovation ecosystems in public organizations over the long term can provide resources to enhance the efficiency and effectiveness of these ecosystems. This includes enabling the quantitative assessment of the effective gains of projects and, consequently, of the innovation ecosystem for spending efficiency in institutions. (2) Cross-cultural comparison: Future research could include a comparative analysis of ecosystem innovation in different cultural and political contexts. This could contribute to understanding the effects of government policies and cultural aspects on the use and effectiveness of these ecosystems. (3) Technological and digital transformation applications: Future research that considers the use of emerging technologies in public sector innovation ecosystems, such as artificial intelligence and its variations, such as generative pre-trained transformer, blockchain, and big data analysis, could contribute to accelerating the development and effectiveness of innovations in these ecosystems. (4) Ecosystem for efficiency: More research is needed to improve the understanding of the application of the ecosystem for efficiency. A new ecosystem model focusing on improving the efficiency of the organizations that integrate it should be developed.

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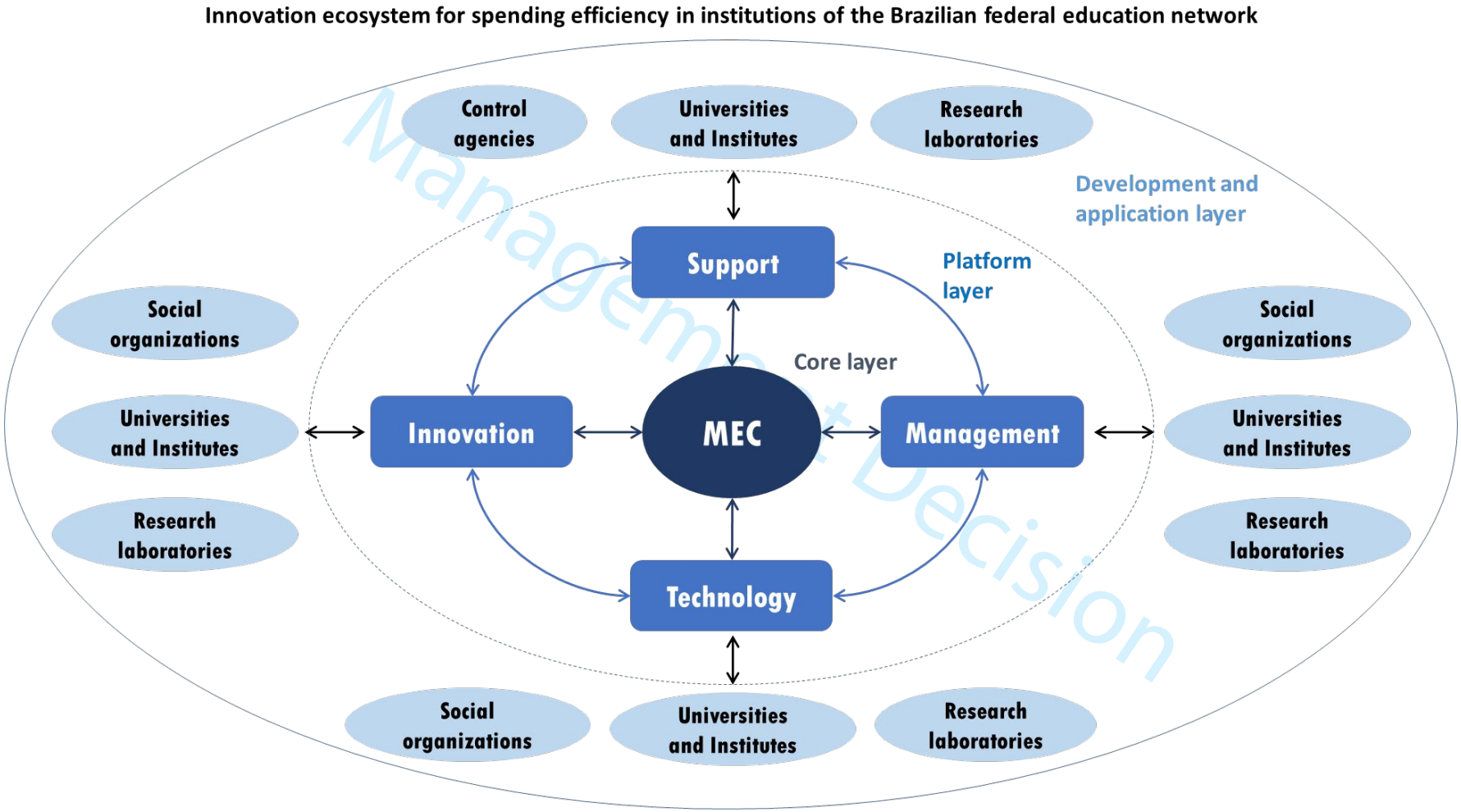
Table 1: Details of the phases, stages, and activities of the study

Identification of phases and stages		Form of execution and data collection
1. Plan the action research	Start the action research project	**Beginning of action research:** Initiation directed by the researcher.
	Define the theoretical conceptual framework	**Theoretical framework:** A literature review of the innovation ecosystem and the efficiency of public spending was developed (Section 2).
	Select the analysis units and data collection techniques	**Unit of analysis:** Secretariat of Higher Education (SESu) and Secretariat of Professional and Technological Education (SETEC) of the Ministry of Education (MEC).
		Data collection technique: Participant observation and document analysis.
	Define the context and purpose	**Research problem:** For the contribution and cooperation of the institutions of the Brazilian federal education network (Federal Universities and Institutes), can the development of an innovation ecosystem make it possible to reduce the expenses of these institutions?
		General objective: To develop an innovation ecosystem to improve the efficiency of public spending in institutions of the Brazilian federal education network.
2. Collect data		**Methods of collection:** Weekly meetings between the researcher and the participants.
		Tools used: Microsoft Teams, electronic spreadsheet, text editor, and an electronic information system.
3. Analyze the data and plan actions		**Data analysis:** Cooperation with the SESu and SETEC, coordinated by the researcher.
		Action plan: Developed; contains the justification, benefits, results, expected deliveries, risks, actions, deadlines, and responsibilities for each action.
4. Implement actions		The action plan was implemented at the SESu and SETEC and was participated by experts from the Project Management Unit, the Projects and Processes Office, the Board of Network of Federal Institutions of Higher Education, and the Board of Development of the Professional, Scientific, and Technological Education Network.
5. Evaluate results and generate report		In this phase, meetings were held between the researcher and collaborators from the secretariats (SESu and SETEC) of the MEC, and presentations were made to the management and groups interested in the research, including universities and federal institutes. Final research reports were generated with the structuring of the ecosystem and the implemented

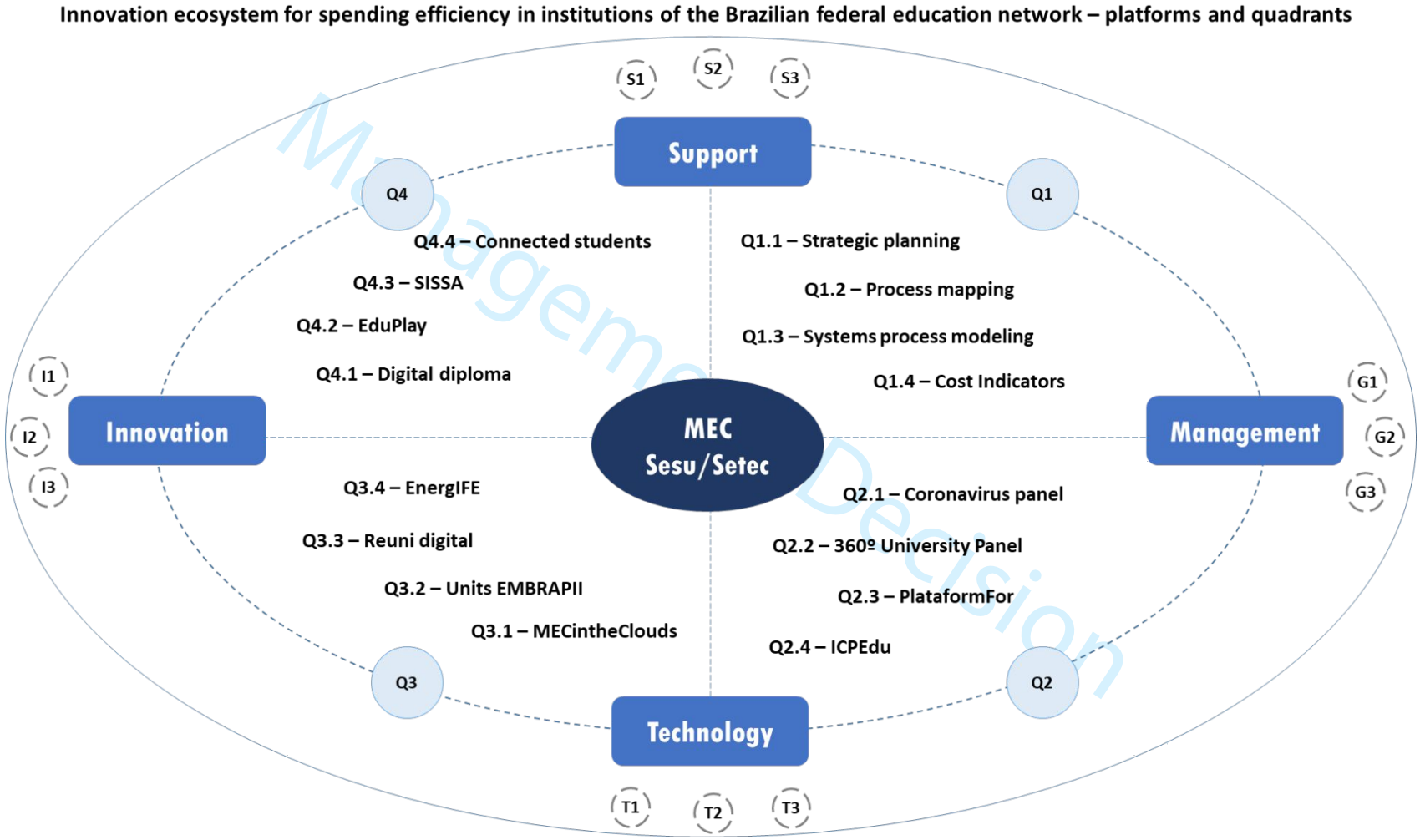
Source: Prepared by the authors and adapted from Mello et al. (2011).

Figure 1: Model of an innovation ecosystem for public spending efficiency in the institutions of the Brazilian federal education network



Source: Prepared by the authors based on the work of Su et al. (2018).

Figure 2: Representation of quadrants and main projects of the innovation ecosystem for spending efficiency in the Ministry of Education



Source: Prepared by the authors based on the work of Su et al. (2018).

Table 2: Short description and main benefits/qualitative impacts of the projects

Project	Status	Short description	Main benefit/qualitative impact
Strategic planning	New	Consolidates the strategic planning of the areas involved.	Optimization and improvement of secretariat processes. Optimization of use of public resources. Transparency in data and in the actions of the secretariats. Effectiveness of the National Policy on Vocational and Higher Education.
Process mapping	New	Maps and improves processes, internal controls, and the management of administrative routines.	
Systems process modeling	New	Process modeling of information technology systems in the areas.	
Cost indicators	New	Analyzes and proposes revisions of cost indicators for institutions.	
Coronavirus panel	New	Panel to monitor the operation and support the performance of institutions in facing the coronavirus pandemic.	Transparency and monitoring of data (operations and actions) during the pandemic period.
360º University panel	New	Development of Big Data analytics solutions for the analytical management of academic indicators, budget execution, and personnel development for the federal higher education network.	Transparency and monitoring of data (budget, staff, and academics) of universities.
Plataform For	Incorporated	Cloud platform to support the Institutional Development Plan (ForPDI) and Risk Management (ForRisco) of the institutions.	Improved management with the preparation and monitoring of the institutional development plan and risk management.
ICPEdu	Incorporated	Uses the public key infrastructure and enable the digital signature of the entire academic community (managers, professors, technicians, researchers and students).	Use of digital certificates to sign digital documents and access systems securely.
MECintheClouds	Incorporated	Program for the digital transformation of institutions in the Brazilian federal education network, with the aim of accelerating the provision of digital services and solutions.	Digital transformation processes and the structuring of cloud services, improving services and reducing spending.
EMBRAPII units	Incorporated	Promotes research, development, and innovation projects within the institutions of the Brazilian federal education network.	Qualify the relationships between institutions and industrial companies, generate efficiency for research, development, and innovation.

Reuni digital	New	Expands students' access and permanence in public higher education through distance education and ensure the quality of the offer.	Expand students' access and permanence in higher education through distance education and new technologies.
EnergIFE	Incorporated	Program for development in renewable energy and energy efficiency.	Development and training in renewable energies and energy efficiency.
Digital Diploma	Incorporated	Modernizes the procedural flow for the issuance and registration of diplomas, initially in the higher education institutions of the federal education system.	Better control and greater agility in the process of issuing and registering diplomas.
Eduplay	Incorporated	University platform for audiovisual content for education and research.	Storage of videos and other audiovisual materials, exempting the institution from the need to maintain this service locally.
SISSA	New	Academic Success Support Integrated System (SISSA in Portuguese) is a platform based on artificial intelligence used to support students, together with the educational institution, in building a successful trajectory in their course.	Prevention and reduction of truancy.
Connected students	New	Provision and monitoring of data packages in personal mobile services for students with socioeconomic vulnerability of institutions.	Allowed students who were socioeconomically vulnerable to access data and videos of classes during the pandemic period.

Source: Prepared by the authors.

Table 3: The main projects and their websites, objectives, and results

Project	Website	Main Goal	Main result/efficiency improvement
Coronavirus panel	https://www.gov.br/mec/pt-br/coronavirus/rede-federal	Assisted the manager in making the decision to resume face-to-face activities, as it presented data on the impact of the new coronavirus pandemic in the cities where the institution has a campus.	Focus on decision-making through the monitoring panel and the sharing of information on the actions of the federal universities and institutes.
360º University panel	https://www.gov.br/mec/pt-br/universidade360	A higher education knowledge platform that provides integrated data and academic, budgetary, and people management indicators from federal universities.	Strengthen the governance of institutions by increasing the assertiveness of decisions and reducing the response time of public policies.
Plataform For	https://www.gov.br/mec/pt-br/plataformafor	Provides a cloud platform to support the institutional development plan and risk management of the institutions.	Provide greater transparency and efficiency in the follow-up process of institutional planning and risk management at federal universities and institutes.
ICPEdu	https://www.gov.br/mec/pt-br/icp-edu	Allows the entire academic community (managers, professors, civil servants, researchers and students) to digitally sign.	Through digital signatures, it will be possible to support the automation of projects and processes and provide support for management.
Reuni digital	https://www.gov.br/mec/pt-br/reunidigital	Expands access and encourages the permanence of students in higher education through distance education.	Expands access and quality training to higher education courses for the population, contributes to the inclusion policy by helping in the entry and retention of students with socioeconomic vulnerability.

EnergIFE	http://energif.mec.gov.br/	A program for the development of renewable energy and energy efficiency in federal educational institutions	Drives the expansion of infrastructure for laboratories and the acquisition of plants for the generation of renewable energy; seeks greater efficiency in the use of energy; encourages, evaluates, and disseminates the implementation of energy efficiency initiatives to ensure greater efficiency in public spending and the use of natural resources.
Digital Diploma	http://portal.mec.gov.br/diplomadigital/	An innovation in the academic environment that enables the modernization of the procedural flow for issuing and registering diplomas in the federal education system.	Issuance and registration of diplomas in digital form.
Eduplay	https://www.gov.br/mec/pt-br/eduplay	Eduplay is the largest video portal for higher education in Brazil. The platform brings together more than 40,000 videos related to teaching, research, and extension. It also allows live streams.	Access to exclusive content focused on teaching, research, and extension. Using adaptive transmission technology, it is possible to reach students with low-quality internet access and deliver audiovisual content with the resolution that best applies to the quality of the internet of each student.
SISSA	https://sissa.ufg.br/	Platform based on artificial intelligence that combines academic data integration, student success prediction, tutor training, and peer interactions in a system that supports students, together with the educational institution, in building a successful trajectory in their course.	Artificial intelligence computational solutions to act preventively in the evasion of Institutions of the Federal Education Network.

Connected students	https://www.gov.br/mec/pt-br/alunosconectados	Provided data packages in personal mobile services for students with socioeconomic vulnerability in the institutions of the federal education network for the development of their academic activities in the context of the COVID-19 pandemic.	Developed because of the COVID-19 pandemic and allowed savings due to the national contracting of internet chips for students with socioeconomic vulnerability. Approximately 150,000 students were served.

Source: Prepared by the authors. Websites are in Portuguese; last accessed on 04/23/2024.

Table 4: Savings generated in the projects implemented in the innovation ecosystem

Project	Estimated total spend predicted without the ecosystem	Total spending with the ecosystem	Generated savings
Plataform For	$ 899,461.95	$ 229,191.09	$ 670,270.86
Digital Diploma	$ 2,184,466.02	$ 279,611.65	$ 1,904,854.37
ICPEdu	$ 677,674.76	$ 194,174.76	$ 483,500.00
Connected students	$ 20,818,585.70	$ 2,732,780.97	$ 18,085,804.73
Total	**$ 24,580,188.43**	**$ 3,435,758.47**	**$ 21,144,429.96**

Source: Prepared by the authors.