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Technological Article

Network as A Strategy to Break Silos and Promote Open Innovation

Red Como Estrategia Para Romper Silos y Fomentar la Innovación Abierta

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ABSTRACT

Objectives: The central objective of this paper is to propose and test a model for the development of network governance structures to respond to the silo effect in the innovation management process in a large research organization. **Method:** A case study was used with the objective of building a governance model that could address the problems derived from the silo effect. To achieve the objective, validation workshops were held, with teams being challenged to reflect on the mechanisms and basic rules used to assemble the model. **Results:** The efforts made to inhibit the silo effect in the organization investigated were successful. Internal events were held to exchange knowledge between research centers, which resulted in greater stimulation of connections between these and other actors throughout the innovation ecosystem. **Conclusions:** The governance model adopted to mitigate the problems derived from the silo effect proved to be effective in promoting interaction between research centers on issues related to open innovation. The model, supported by mechanisms and basic rules inserted in the key actions, proved to be efficient in promoting a more intense relationship between the research units of the institution studied, resulting in new network actions.

Keywords: networks and alliances; innovation management; open innovation.

RESUMEN

Objetivos: Este trabajo tiene como objetivo central proponer y testear un modelo para el desarrollo de las estructuras de gobernanza en red, para dar respuesta al efecto silo en el proceso de gestión de la innovación en una organización pública de investigación. **Método:** Fue utilizado un estudio de caso en una gran institución de investigación, con el objetivo de construir un modelo de gobernanza que pudiera abordar los problemas derivados del efecto silo. Para lograr el objetivo, han sido realizados talleres de validación con equipos que tenían el trabajo de reflexionar sobre los mecanismos y las reglas básicas que forman parte del constructo. **Resultados:** Los esfuerzos realizados para inhibir el efecto silo en la organización investigada surtieron efecto. Se realizaron eventos internos para intercambiar conocimiento entre centros de investigación, lo que resultó en un mayor estímulo de las conexiones entre estos y otros actores del ecosistema de innovación. **Conclusiones:** El modelo de gobernanza adoptado para mitigar los problemas derivados del efecto silo demostró ser eficaz para fomentar la interacción entre los centros de investigación en temas relacionados con la innovación abierta. El modelo, apoyado en mecanismos y reglas básicas contenidas en las acciones clave, demostró ser eficiente para promover una relación más intensa entre las unidades de investigación de la institución estudiada, resultando en nuevas acciones en red.

Palabras clave: redes y alianzas; gestión de la innovación; innovación abierta.

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INTRODUCTION

One of the most important factors for a public science, technology, and innovation (ST&I) organization is the development of high-impact innovations. To achieve this, it is necessary to create the internal conditions and structures that facilitate the innovation process, which requires management and, of course, the integration of different actors (Quinhoes & Lapão, 2024).

To facilitate internal integration in the innovation process, authors highlighted the relevance of forming intraorganizational networks (Bygballe & Ingemansson, 2014; Briody & Erickson, 2014; Hanifah et al., 2020; Sanchez-Famoso et al., 2014; Whelan et al., 2011). Briody and Erickson (2014) and establishing collaboration as one of the five central pillars of the innovation success model throughout the innovation system. Without connection between the parts (i.e., the silo effect), the innovation process could not be sustained

It is necessary to continue developing the study of networks as a science and integration of knowledge is important in terms of forms (e.g., similar contexts) or contents (e.g., research approaches). Thus, in addition to the intentional development of intraorganizational networks being seen as an important management and strategy tool to break the silo effect, the accumulated different theoretical contributions that are connected to the object of study of this paper are also a result.

The context of this article, and the object of this study, is related to the development process of a management model for the open innovation process at the Brazilian Agricultural Research Company (Embrapa). The company includes 43 research centers with serious difficulties of integration between these units, which were identified through an in-depth interview process in this organization. The proposed model is, therefore, focused on facilitating partnership work between Embrapa centers, and between them and other actors in the Brazilian agricultural innovation ecosystem.

To enable bibliographic research and the design of the model, the following question has been defined as a central problem:

> What are the mechanisms and basic rules for the development of an intraorganizational network and its contribution to breaking silos in the innovation process in ST&I organizations?

Taking as a reference the life cycle of networks and alliances proposed by Stott and Keatman (2005), this article makes a non-exhaustive compilation of the contributions of different authors who usually investigate networks from the approach of economic sociology in order to instrumentalize the design and implementation of these networks. The central objective of this work is thus to propose and test a model for the development of governance structures in a network, based on ten basic mechanisms and rules, and to respond to the silo effect in the innovation management process in a public research organization having great complexity in its value generation process.

From a theoretical point of view, the study of network governance structures is justified because it can provide important elements of analysis that help in the understanding of the dynamics of large organizational structures in the innovation management process. The complexity of these types of organizations challenges researchers and academics to seek conceptual proposals capable of combining skills from specific areas into innovative solutions for the organization as a whole and preventing knowledge and synergy from being lost due to the silo effect. In managerial terms, the study brings benefits by presenting, in its methodological proposal, tools such as workshops and brainwriting, which, once applied, can contribute to the participatory development of innovation management structures, involving people and knowledge from different areas, promoting interaction between them and thus dealing with the silo effect.

CONTEXT INVESTIGATED

To achieve the objectives of this research, a case study was initiated in the Brazilian Agricultural Research Company (Embrapa), a research organization with national and international reputation in the area of agribusiness, the fruits of whose work began to appear in the 1970s by transforming agriculture in Brazil through science and technology. It is a company with an organizational structure complex enough to serve as a basis for ongoing research.

Embrapa was created in 1973 as the central institution of the National Agricultural Research System (SNPA, its acronym in Portuguese), with the intention of promoting agricultural research and integration between institutions in the sector (Pereira & Castro, 2020). From the beginning, the company was concerned with acting as a network, as it was born alongside all the structures of the National Department of Research and Experimentation in its heritage. The company

had independent research institutes that have been transformed into the first research centers of Embrapa (https://www.embrapa.br/memoria-embrapa/a-embrapa). Furthermore, considering the current importance of agriculture for the composition of the Brazilian gross domestic product (GDP), which accounts for 23.8% of the indicator in 2023 (https://www.cepea.esalq.usp.br/br/pib-do-agronegocio-brasileiro.aspx) the importance of studying phenomena connected to innovation management in the company that is the leading member of the SNPA is clear.

Although Embrapa was created with a concern for network action, in the in-depth interview process carried out between May 21 and December 14, 2021, it was possible to perceive the silo effect in the interaction between the research centers. According to the perception of the 15 interviewees, there is a lack of dialogue between Embrapa's research centers. These centers usually act in the open innovation process by focusing only on their own needs, which results in the majority of the company's open innovation initiatives having the participation of only one research center (Favarin et al., In press).

In methodological terms, the case study as a research method finds support in the work Yin (2014). From this method, the researcher is able to understand a phenomenon in one or several units studied through the so-called 'evidence,' which can include interviews with the people involved, access to documents and objects, participant observation, direct observations, among other aspects.

The focal point of the case study protocol was the holding of three workshops between February 15 and 24, 2022, with the participation of 15 professionals (Table 3), who were chosen for their important participation in the Embrapa innovation process. They represented eight research centers and the central office (Corporate Headquarters). These workshops aimed to test a proposed governance structure design model that could mitigate the silo effect in Embrapa's open innovation process

Participatory techniques including brainwriting and discussion of the contributions of workshop attendees were used to generate deeper reflection. The script used was developed through bibliographic research taking as a starting point the understanding of the stages of the life cycle of networks and alliances proposed by Stott and Keatman (2005), This was combined with the contributions of different authors on mechanisms and basic rules (Table 2), in order to instrumentalize the design and implementation of intraorganizational networks.

This article is designed in accordance with a qualitative approach, a method used to investigate any phenomenon related to social reality (Pérez Andrés, 2002). Bibliographic research, as a qualitative method, was used to investigate the contributions of network and alliance governance structures responding to the silo effect in the innovation management process, and to systematize the mechanisms and basic rules for building a network or alliance in its initial stages of development. In addition, it was decided to hold workshops to design the governance model of the Embrapa Network in Business for Innovation, applying the concepts presented in the literature review.

To carry out the bibliographic research, we had access to the virtual repository of articles and international journals of the Coordination for the Improvement of Higher Education Personnel — Capes (newspaper portal), a Brazilian platform, being thus able to search for articles using terms related to networks such as: internal networks, life cycle of networks and alliances, breaking silos, destruction of silos, silo busting, innovation management.

Bibliographic research was carried out between the months of August 2021 and February 2022. After the selection of the articles, their reading and analysis, the text that gave rise to the theoretical basis was elaborated in order to present content using complementary concepts to explain social phenomena and their dynamic.

DIAGNOSIS OF THE SITUATION

Networks in the innovation process of an organization

The study of networks has intensified in recent decades, with important contributions in different areas of knowledge. Emphasis must be placed on studies focused on graph theory (Bollobas, 1998), communication (Monge & Contractor, 2003), biology (Barabási & Oltvai, 2004), physics (Barabási, 2002; Pastor-Satorras & Vespignani, 2004), sustainable development (Stott & Keatman, 2005); sociology (Granovetter, 1973) and economic sociology (Owen-Smith & Powell, 2008; Uzzi, 1996; Uzzi, 1997). This article is closely linked to the sociological perspective, but above all to economic sociology, in that the innovation process may be considered part of the productive-economic process of an organization.

According to Smith-Doer and Powell (2005), the study of networks in the economic sociology literature varies widely, depending on the role it assumes. Firstly,

because social ties and economic exchange are strongly intertwined; networks can represent informal relationships in the labor market. This can cause activity on these networks to be influenced by friendship, reputation, and trust. Secondly, networks are formal exchanges, both in terms of pooling assets and providing resources that involve continuous interaction to obtain value in return. And thirdly, networks constitute a relational form of governance through which authority is dispersed. These types of agreements are usually associated with environments in which both markets and environments can change frequently, with priority on adaptability.

Different authors have worked on the three major areas of the study proposed by Smith-Doer and Powell (2005) in the direction most connected to this study (i.e., internal networks as part of the innovation process in an organization). Since this article is focused both on the formal networks that participate in the innovation management process and on the relational aspect of the networks through which authority is dispersed, our focus will be on Smith-Doer and Powel's approaches 2 and 3.

Bambini et al. (2014) present the evolution of collaborative innovation perspectives since the 1980s, highlighting that innovation networks are flexible organizational arrangements that involve interorganizational relationships that can generate several advantages for organizations. The authors highlight how these networks can adopt different formats and nomenclatures — such as associations for research and development, strategic alliances, joint ventures —, adapting according to the interests, skills, competencies, and resources of the parties and being influenced by institutional and economic environments, context, and regulatory aspects of the sector involved.

The open innovation approach, proposed in the 2000s by Chesbrough (2003), considers that organizations can and should use external and internal resources and ideas to promote and advance their innovative practices. With this in view, it is possible to share the risks and costs of a R&D process, obtaining available talent, technology, resources, and human capital from partner organizations (Sikandar et al., 2023).

The review work by Sikandar et al. (2023), on trends in the development of research related to open innovation, shows that 'network' is an important keyword associated with the topic. The authors highlight that a network offers an important channel for communicating business information, allowing not only the exchange of resources, but also the formation and consolidation of new relationships.

In the open innovation process, especially in the connection between the internal and external environments, Whelan et al. (2011) have identified three internal roles (i.e., idea explorers, idea connectors, and innovation engineers) that connect in sequence with external knowledge sources (Figure 1). The process of technological development within the limits of the organization is thus launched online, with the role of connector demanding special attention, and this is why importance is given to the connection with different professionals and areas in the organization, as can be seen next.

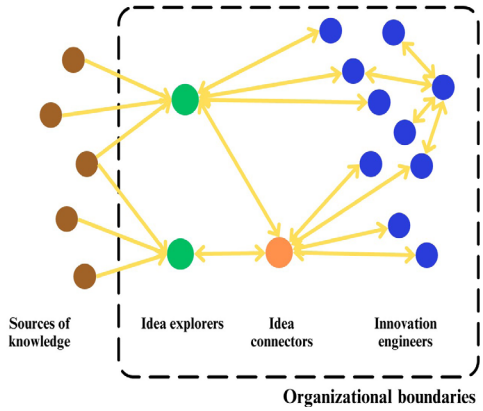

Figure 1. The critical role of connectors.

Source: based on Whelan, E., Parise, S., De Valk, J., & Aalbers, R. (2011). Creating employee networks that deliver open innovation. MIT Sloan Management Review, September 21. https://sloanreview.mit.edu/article/creating-employee-networks-thatdeliver-open-innovation/

Hanifah et al. (2020) have studied the internal factors that impact the innovation process of small and medium-sized companies (SMEs). The results indicate that intraorganizational social networks have a significant impact on innovation culture and indirectly impact innovation performance. It is thus in the organization's interest to facilitate effective internal social networks (Hanifah et al., 2020).

Similarly, the study by Bygballe and Ingemansson (2014), focused on the construction industry, while that by Sanchez-Famoso et al. (2014), focused on family businesses, demonstrating the importance of strengthening intraorganizational networks for the development of new solutions. Therefore, the innovation management process must understand the construction of internal bridges as an important strategy to connect people who work in association and can generate organizational results.

The case presented by Andrade et al. (2021) highlights that collaborative governance, oriented toward consensus among the actors involved in a network, plays an important role in the implementation and conduct of networks formed to promote innovation. According to the

authors, elements that structure collaborative governance include: inter-institutional management, initial conditions for collaboration, facilitation and leadership, institutional design, and collaborative processesos.

Interinstitutional management involves managing interactions between actors, defining roles and responsibilities, aligning interests, and establishing communication processes and channels. Andrade et al. (2021) highlight that, at the beginning of collaborative network activities, there are generally asymmetries of power, resources, and knowledge. Any conflicts that exist must be addressed and relationships of trust built between the parties involved. Choosing a facilitating leader with mediation skills is very important for the process, in order to give participants a voice and open channels of dialogue.

The institutional design, according to Andrade et al. (2021), happlies to the governance mechanisms established in the network as a means of formalizing established relationships and clearly defining the roles of the participants and the work rules. This structural design must provide legitimacy for collaboration and transparency for participants.

The authors also highlight that network collaboration is based on dialogue and the existence of motivation and/or common purpose, with the aim of achieving collective results of much greater impact than results generated in isolation.

Schepis et al. (2021) highlight that the academic literature on open innovation generally focuses on the company level. There are few studies focused on the management of broader networks involved in this process and their forms of governance. This work seeks to contribute to the study of this topic.

Life cycle of networks and alliances, their mechanisms and basic rules

The present study is focused on the framework of formal intraorganizational networks, formed as part of the strategy to break down silos in the innovation process of an organization. Thus, in line with the intentionality in the layout of associative work, it is essential to take into account the life cycle of a network and its initial stages of development.

Networks are the subject of analysis in different areas and it is important to be attentive to contributions that can help integrate knowledge and represent advances in the study of networks as a science. With this as an objective, the studies carried out by Stott and Keatman (2005), efocused on the life cycle of pro-sustainability multi-actor alliances (Figure 2 and Table 1), presenting the essential elements for understanding the life cycle of a network or alliance in general (i.e., internal or external), as presented following.

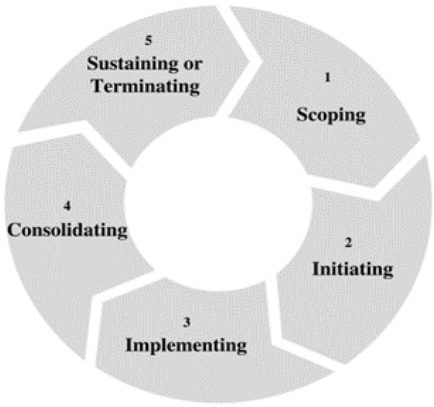

Figure 2. Life cycle of networks and alliances.

Source: based on Stott, L., & Keatman, T. (2005). Tools for exploring community engagement in partnerships. In *Building Partnerships for Development in Water and Sanitation (BPD)*. London, UK. https://www.bpdws.org/web/d/doc_267.pdf?statsHandlerDone=1

Figure 2 is a visual representation of the understanding of networks and alliances as mechanisms that have a life cycle, that is, they have been created for a reason and that in the course of their evolution they may result in continuation or termination of organizational formation. So the first stages (1 and 2) are more focused on establishing the beginning of the partnership work, the intermediate stages are concerned with implementing and perfecting the partnership work (3 and 4), and the final stage (5) is focused on evaluating the work and defining the next steps. Table 1 presents the key actions related to the stages of the life cycle of networks and alliances.

Table 1. Life cycle of networks and alliances and key actions.

Stages	Key Actions
Scoping	Investigate the context
	Select partners
	Analyze strengths and weaknesses
	Analyze value and risks
Initiating	Establish basic rules
	Agree on principles, objectives, and goals
	Establish functions and structures
Implementing	Monitor the completion of tasks
	Develop or review decision-making structures
Consolidating	Refine methods of working together
	Ensure long-term commitment and continuity
Sustaining or Terminating	Making decisions about what should happen next
	Conclusion or development of additional work

Note. Source: based on Stott, L., & Keatman, T. (2005). Tools for Exploring Community Engagement in Partnerships. In Building Partnerships for Development in Water and Sanitation (BPD): London, UK. https://www.bpdws.org/web/d/doc_267.pdf?statsHandlerDone=1).

In the stages of network and alliance development proposed by Stott and Keatman (2005), the main concern is with the functioning, dynamics, and key actions in the life cycle of networks and alliances. Considering that the silo effect is the fragmentation between the parties, looking at Table 1 indicates the concern to avoid it and demonstrates the adequacy and contributions of the study by Stott and Keatman (2005) in this work.

In the second stage (initiating), there is a concern to establish the basic rules for collaboration, as well as agreeing or establishing principles, objectives, goals, functions, and structures. The same concern can be seen in stage 3 (implementing), with the development or review of decision-making structures, and in step 4 (consolidating), with the idea of refining methods for working together.

For the creation of a network or alliance, it is essential to establish mechanisms and basic rules for its operation. It is then possible to see (in Table 2) the contributions of different authors that, from an integrative perspective, help in understanding how to design partnership work. The basic mechanisms and rules consist of a series of procedures that allow and encourage work in an interactive manner, being an appropriate format for the functioning of networks and alliances. These resources favor the connection between different participants even in situations of management complexity that normally characterize the context of networks and alliances.

Table 2. Initial stages of the life cycle of networks and alliances: key actions, mechanisms, and basic rules.

Stages	Key Actions	Mechanisms and Basic Rules
Scoping	Investigate the context Select partners Analyze strengths and weaknesses Analyze value and risks	Selection and integration of partners
Initiating	Establish basic rules for collaboration	Formalization Generation of incentives Promotion of interaction
	Agree on principles, Objectives, and goals	Planning and definition of processes and routines Distribution of results Control, monitoring, and evaluation
	Establish functions and structures	Definición de roles y responsabilidades Resolución de conflictos Decision-making process

Note. Source: own authorship, taking into account the contributions of different authors.

In Table 2, it can be seen the concern for the development of networks and alliances with very well-connected actors, with mechanisms such as selection and integration of partners (Arranz & Arroyeba, 2007; Henttonen et al., 2016; Stott & Keatman, 2005), formalization (Cristofoli & Markovic, 2016; Álvarez et al, 2010), and promotion of interaction (Álvarez et al, 2010; Cristofoli & Markovic, 2016; Mariani, 2016). Another important aspect is related to the mechanisms and basic rules for the proper functioning of partnership work, with the planning and definition of processes and routines (Mariani, 2016; Roberts, 2011), control, monitoring, and evaluation (Álvarez et al, 2010; Dimitratos et al., 2010; Roberts, 2011; Stott & Keatman, 2005), generation of incentives (Lavikka et al., 2015; Wegner et al., 2013), decision-making process (Dimitratos et al., 2010; Lavikka et al., 2015; Mariani, 2016; Stott & Keatman, 2005), definition of roles and responsibilities (Arranz & Arroyeba, 2007; Mariani, 2016), conflict resolution (Gardet & Fraiha, 2012), and distribution of results (Dhanaraj & Parkhe, 2006; Gardet & Mothe, 2011; Park & Ungson, 2001).

The work of Stott and Keatman (2005) is fundamental to understanding the life cycle of networks and alliances, so Figure 2 and Table 1 would be sufficient if this work is focused on analyzing the life cycle of an alliance or network. However, taking into account that this article is intentionally focused on the process of designing governance of a network or alliance, it is important to add the concept of mechanisms and basic rules that permit the establishment of dynamics and investigation of important elements for the creation, or co-creation, of the management model.

Although the mechanisms concerned with the connection between partners could be understood as the most important elements for confronting the silo effect, it is essential to be clear that all the mechanisms and basic rules are relevant, since not using them may generate distance between partners (e.g., if there is no perception of justice in the distribution of results, one of the partners or many of them may not feel motivated to work in an associative way, which is far from the idea of network or alliance).

Silos arise because social groups and organizations have particular conventions about how to classify the world (Tett, 2015, p. 36). Therefore, the problem is that many of the institutions are highly departmentalized and made up of an infinite number of business units, which can increase the risk of the silo effect occurring within the framework of the organization itself. Thus, working in partnership can be seen as an important action strategy in the case of Embrapa.

PROPOSED INTERVENTION: THE EMBRAPA NETWORK IN BUSINESS FOR INNOVATION

The governance model design process

To carry out the workshops with the objective of designing the network governance model, the work of Stott and Keatman (2005), was used for the life cycle of networks and alliances (Figure 2 and Table 1), in addition to the contributions of different authors on the mechanisms and basic rules for associative work (Table 2). This work is limited to the scoping and initiating stages of the life cycle to form a relationship between the key actions and the basic mechanisms and rules.

On February 15, 21, and 24, 2022, workshops were held with 15 Embrapa employees, chosen for their important participation in the company's innovation process; they were representative of 25% of Embrapa's research centers. In addition, a significant number of the attendees were researchers on the topic. They were asked to reflect on each of the ten mechanisms and basic rules (Table 2) in this research, thus contributing to the testing of the model of the governance of networks and alliances proposed in this article. The profile of the workshop attendees can be seen in Table 3.

Table 3. Profile of workshop attendees.

Employee	Functional Role/Position at Embrapa	University Education/Experience in Innovation
1	Supervisor — environments, networks, and initiatives team (corporate)	Degree in psychology. Experience in agile methods, group facilitation, innovation, and business, in addition to establishing relationships with ecosystem actors.
2	Analyst — environments, networks, and initiatives team (corporate)	Official master's degree in development (research focused on networks and alliances). Experience in the development of innovation initiatives, in innovation and development networks, in addition to establishing relationships with ecosystem actors.
3	Researcher — environments, networks, and initiatives team (corporate)	Official master's degree and doctorate in agronomy. Experience in innovation processes, technology transfer, and relationships with ecosystem actors.
4	Researcher — environments, networks, and initiatives team (corporate)	Official master's degree and doctorate in economics. Experience in innovation processes, technology transfer, and relationships with ecosystem actors.
5	Analyst — environments, networks, and initiatives team (corporate)	Official master's degree and doctorate in administration (research focused on networks). Experience in innovation processes, technology transfer, and relationships with ecosystem actors.
6	Supervisor — innovation partnership structuring team (corporate)	Official master's degree and doctorate in zootechnics. Experience in development of innovation initiatives, establishing relationships with ecosystem actors.
7	Analyst — technology transfer team (research center)	Official master's degree and doctorate in scientific and technological policy (research focused on innovation networks). Experience in development of innovation initiatives, establishing relationships with ecosystem actors, and innovation management.
8	Supervisor — communication team (research center)	Official master's student in administration (research focused on innovation). Experience in development of innovation initiatives, startup mentoring.
9	Head — technology transfer team (research center)	Unofficial master's degree in innovation, official master's degree in agronomy. Experience in development of innovation initiatives, establishing relationships with ecosystem actors.
10	Supervisor — technology transfer team (research center)	Official master's degree and doctorate in aquaculture. Experience in developing innovation initiatives, in addition to establishing relationships with ecosystem actors.
11	Analyst — technology transfer team (research center)	Official master's degree and doctorate in chemistry. Experience in design and organization of innovation initiatives, establishing relationships with ecosystem actors.
12	Analyst — communication team (research center)	Degree in public relations. Experience in development of innovation initiatives, establishing relationships with ecosystem actors.
13	Head — technology transfer team (research center)	PhD in administration. Experience in development of innovation initiatives, establishing relationships with ecosystem actors.
14	Analyst — technology transfer team (research center)	Official master's degree in administration (research focused on innovation networks and alliances).
15	Coordinator — digital innovation team (corporate)	Official master's degree in knowledge management. Experience in establishing relationships with ecosystem actors.

The model proposed and tested in this article for the design of network and alliance governance is shown below, in Figure 3. As can be seen, the elements presented in Table 2 have been transformed into a framework that aims to present the sequential organization of the design process launched.

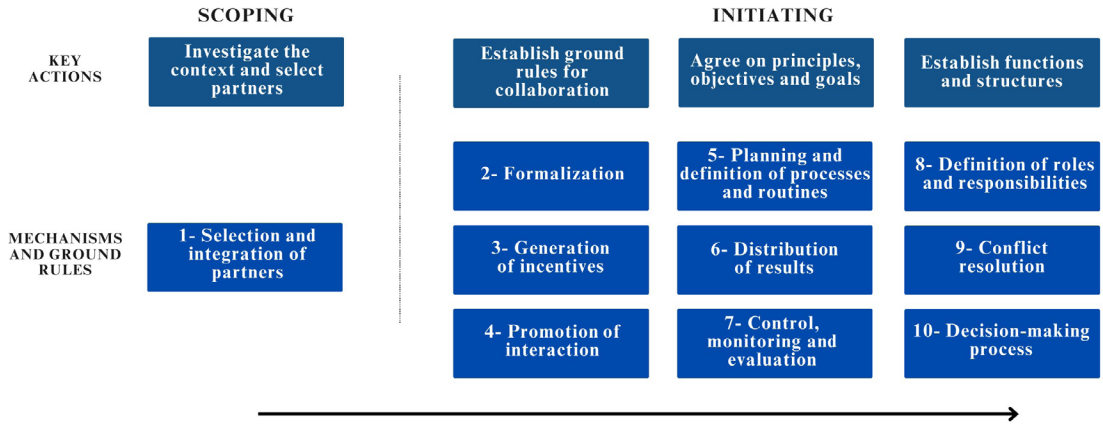

Figure 3. Proposed model for the design of the governance of a network or alliance.

To facilitate the implementation of the workshops, the brainwriting technique was used, where attendees write their contributions, with joint discussion and reflection being carried out at the end. Representation of the process can be seen in Table 4 below, including the review stage of the attendees' contributions.

Table 4. Representation of the process used in the workshops.

Mechanisms and Basic Rules	Questions
1. Selection and integration of partners	Who is part of governance? Who is part of the network? What are the integration tools or strategies?
2. Formalization	How is participation in governance formalized? How is participation in the network formalized?
3. Generation of incentives	How to generate incentives for participation in the network? What are the important incentives for network participants?
4. Promotion of interaction	How to promote interaction between network participants? How to establish and promote interaction between governance and network participants?
5. Planning and definition of processes and routines	What are the fundamental processes and routines for the network? What are the processes and routines limited to governance? What are the most important routines to keep the network active?
6. Distribution of results	Taking into account that the network has been created to promote the development of actions in association between Embrapa's research centers, how will the results of the association work be distributed?
7. Control, monitoring, and evaluation	What are the performance indicators that will be used to evaluate networking? How and when will the network governance model be reviewed?
8. Definition of roles and responsibilities	What are the roles and responsibilities of those who are part of the governance and those who are part of the network? How can roles and responsibilities foster partnership work between Embrapa research centers?
9. Conflict resolution	How to manage possible conflicts in networking? How are conflicts between those who form governance going to be managed? How will conflicts between those who make up the network be managed?
10. Decision-making process	What is the decision-making process among those who are part of governance?

For the design process, 20 minutes were designated for brainwriting, followed by 60 minutes of discussions for each of the mechanisms and basic rules. Two periods of review of the contributions of the workshop attendees followed, each of 120 minutes

Results: The governance model of the Embrapa Network in Business for Innovation

Based on Stott and Keatman (2005), the governance model proposed in this work is made up of ten basic mechanisms and rules contained in the key actions to be developed as the basis of governance of the Embrapa Business Network for Innovation. These mechanisms and basic rules are presented and described as shown in Figure 3: (1) selection and integration of partners; (2) formalization; (3) generation of incentives; (4) promotion of interaction; (5) planning and definition of processes and routines; (6) distribution of results; (7) control, monitoring, and evaluation; (8) definition of roles and responsibilities; (9) conflict resolution; and (10) decision-making process. The main axes of analysis of the proposed model are based on the items that contain the basic mechanisms and rules, namely: investigate the context/selection of partners; establish ground rules for collaboration; agree on principles, objectives, and goals; and establish roles and structures. The data on the testing of the model proposed in this article are available below, in Figure 3, and Figure 4 represents a summary or visual representation of the governance of the Embrapa Network in Business for Innovation.

Selection and integration of partners

Management Committee

With respect to profile and proportion, employees must work with the topic of open innovation in the research centers, with one person for each region of Brazil, making five contributors, and coordinators of the corporate process, totaling three contributors. With greater participation of employees from the research centers plus the concern for regional representativeness, the Management Committee will have strong links to the different realities. Selection will be made as follows: notification will be given, followed by voting by network members (for employees of research centers); nomination (for corporate process coordinators). Justification: voting is justified, in the case of research center employees, as it confers legitimacy on the committee. As for nomination of corporate process coordinators, this forms part of the role of these employees. Regarding the mandate: one year, extendable for the same period. Maintain at least three people from the previous management. Justification: we must take into account Embrapa's calendar of activities, which is annual, so the employee's role may change at the change of year. It is important to maintain a part of the previous management to minimize the risk of discontinuation of actions.

Advisory Committee

Profile and proportion: external actors (3) and Embrapa employees (2) who can help oxygenate the work of the Management Committee and the network. Justification: take into account concern with oxygenating the work and the fact that it is an intraorganizational network with the potential for impacting external results. It is essential to have a greater participation of external actors in proportion to that of Embrapa employees. Concerning selection: nomination (for external actors and employees). Justification: it would not make sense to vote for the role, so nomination is more appropriate. Regarding the mandate: one year, extendable for the same period. Justification: in addition to Embrapa's calendar being annual, the similar dynamics of the organizations' calendar usually must be taken into account.

Network members

Profile: employees who are involved with the topic of open innovation. Justification: taking into account the objectives of the proposed work, the network must be composed of representatives of the centers. Selection: nomination by research centers. Justification: responsibility of the heads of the Embrapa centers. Mandate: not applicable. Justification: the network member can be changed upon request of the research center.

Formalization

Formalization consists of the following elements: (1) participation of Embrapa employees on the Management Committee or Advisory Committee: creation of a service order and inclusion of the activity as part of integration; justification: forms part of the work process at Embrapa; and (2) innovation hubs: the existence of a cooperation contract between Embrapa and the hubs where interaction is recommended, though not mandatory; justification: the cooperation contract is part of the process of developing joint actions, but cannot be an impediment to the start of the interaction.

Generation of incentives

The generation of incentives occurs as a consequence of the following: increase in research centers results mainly in the number and impact of actions on open innovation. Justification: the perception of improved results is important for research centers, in order for the importance of network

governance to be recognized; communication actions that make the efforts of open innovation research centers visible. Rationale: visibility and recognition of efforts are important to maintain partnership work; training on topics of interest to Embrapa centers. Justification: this is one of the central points for capacity development; improvement in the operation of research centers as regards open innovation. Justification: in addition to provoking new thinking, the proposal is concerned with improving the operation in the centers, and tends to maintain their interest in the network.

Promotion of interaction

The promotion of interaction occurs through the following actions of the committees: Management Committee:

Management Committee: holding biweekly meetings. Justification: whilst always taking into consideration the different demands of the committee members, it is important to: maintain contact between the Management Committee and the network: hold meetings (depending on the need), Embrapa Conecta HUB, workshops, training, exchange of experiences; use internal virtual forum 'Innovation and business.' Each member of the Management Committee will act as facilitator for five focal points. Justification: it is essential to take into account dual-hand mechanisms, which is why there is a preference for spaces for: dialogue between the Advisory Committee and the Management Committee: quarterly meetings, with presentation of the results. Justification: the proposed dynamic is based on the experience of advisory committees of other Embrapa initiatives and it is understood that this constitutes the minimum time necessary to be able to present more concrete results.

Planning and definition of processes and routines

The planning and definition of processes and routines occurs as follows: the governance structure must facilitate the work of Embrapa's research centers and does not have the role or power to limit their operation. Justification: the proposal respects the powers and organizational chart of Embrapa; communication in all governance instances must be clear, direct, and cordial. Justification: in this way, generation of a healthy environment may be expected; quick responses must be given to network members. Rationale: network governance only makes sense if it can support the network as a whole; it is necessary to periodically monitor initiatives and actions in association with innovation hubs and startups. Justification: it is essential to be clear about the contributions and results achieved, so this helps keep the network running; all members of the network are responsible for developing a culture favorable to open innovation. Justification: the network is a space for the development of collective intelligence on the issue of sustainability, in addition to understanding the nodes of the network as representatives of itself; it is necessary to hold meetings with significant frequency, which, although virtual, keep networking active. Justification: it is necessary to have clear and constant work processes.

Distribution of results

For the distribution of results, it is necessary to agree in advance what results are intended to be achieved, and the division will be made proportional to the effort of each actor involved. Justification: prior agreements tend to provide transparency and reinforce trust between the parties.

Control, monitoring, and evaluation

In order to control, monitor, and evaluate, the following actions are necessary: it is necessary to define performance indicators. Justification: by doing this, it will be possible to monitor and evaluate the results of networking; the open innovation initiatives carried out by the Embrapa research centers must be monitored. Justification: support for the scope of results; based on monitoring and evaluation, it is important to make decisions to improve results. Justification: part of networking is the improvement of its action mechanisms, in addition to the definition of new paths; at the meetings of the Management Committee there will be a presentation of the status of the innovation initiatives carried out by the research centers. Justification: it is possible, in this way, to monitor and face possible difficulties; at the Advisory Committee meetings, there will be the presentation of the results. Justification: this is one of the main ways to receive contributions from the Advisory Committee on the work of the Management Committee and the network.

Definition of roles and responsibilities

Management Committee

Regarding the functions of the Management Committee, the following actions are required: (1) respond to the needs of representatives of open innovation research centers; justification: the strength of the network is increased by the support of its parts; (2) facilitate the interaction of research centers with innovation hubs; justification: in this way, the contact of the centers with the hubs is increased; (3) promote collaborative initiatives, taking into account Embrapa's topics of interest and strategic issues; justification: partnership actions must take into account the interests of Embrapa, especially on issues connected to sustainability and project portfolios;

(4) increase the maturity of the network on issues related to open innovation; justification: the network is a space for the development of collective intelligence in open innovation and understands the different realities of the centers on the subject; (5) facilitate the performance of the services necessary to carry out networking: support in the structuring of networks, facilitation of meetings, knowledge management, formalization of partnership initiatives, holding of events and workshops, support for initiatives in association, search for financing, and communication; justification: services are fundamental for the existence and sustainability of the network.

Advisory Committee

Regarding the advisory committee, the actions are as follows: oxygenate the work of the Management Committee and the network. Justification: this is the main reason for the existence of the Advisory Committee, so that an external view can help improve the governance of the internal network.

Network members

Regarding the members of the network, the actions are the following: (1) participation in innovation hubs; justification: it is necessary to provide assistance to the activities of the hub so that it can develop deeper relationships and facilitate the establishment of relationships between the research centers and the hub; (2) mapping of opportunities in innovation hubs for research centers; justification: be part of a rather proactive action by the members of the network, so that based on mapping it is possible to connect different centers to an initiative or transversal need; (3) facilitate the interaction of research centers with innovation hubs; justification: based on the established relationships and taking into account previous experiences with the hub, the representative of each center has legitimacy to facilitate the relationships of the innovation environment with other Embrapa centers.

Conflict resolution

In conflict resolution, the actions would be the following: (1) dialogue as a central element for the resolution of possible conflicts; justification: taking into account that it is an intraorganizational network, it is assumed that dialogue will be sufficient for possible conflicts; (2) search for consensus in decisions; justification: consensus and reflection are important in the decision process, and are thus rather more preventive measures; (3) transparency in all governance instances; justification: transparency is essential so that network members have confidence and feel motivated to continue working in association.

Decision-making process

Regarding the decision-making process, the Steering Committee and the Advisory Committee must reach a consensus among the members based on discussion. When necessary, technical sectors, such as legal, can be invited to help with legal matters, for example. Justification: consensus building with active listening is important so that each member feels important in the decision-making process.

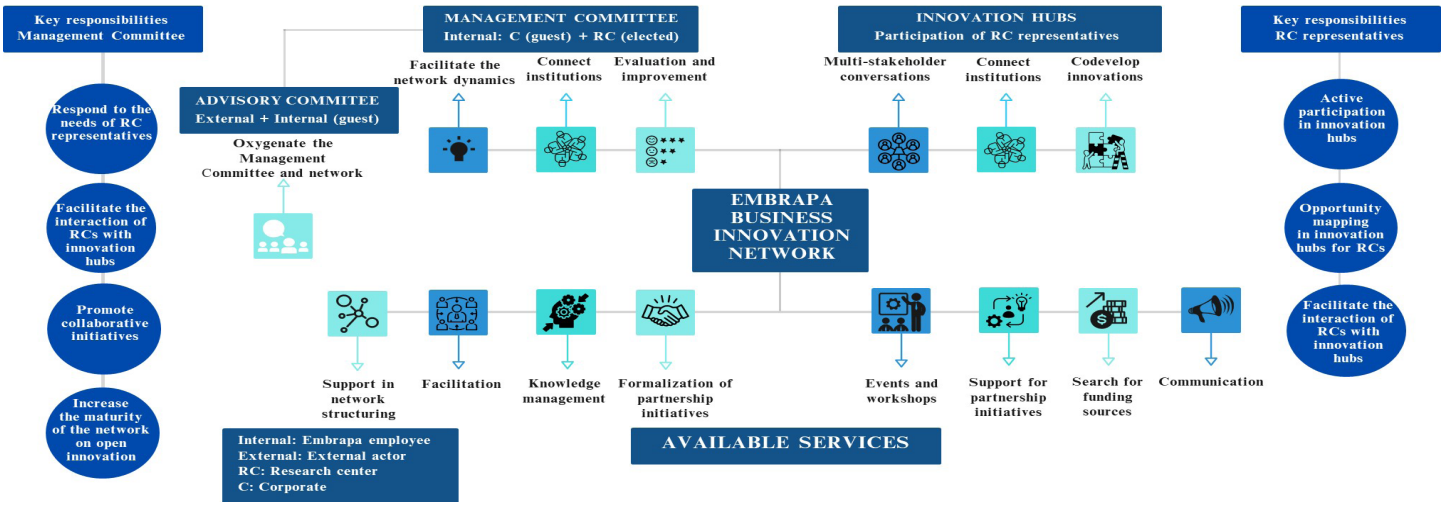

Figure 4. Visual representation of the governance of the Embrapa Network in Business for Innovation (own authorship).

DISCUSSION OF RESULTS

The application of the model based on the ten basic mechanisms and rules seemed adequate for design of the governance of the Embrapa Business Network for Innovation. Thus, the integration of the contributions of different authors, connected to the life cycle of networks and alliances proposed by Stott and Keatman (2005), demonstrates the importance of the interrelation of knowledge in this study.

However, in the opinion of the authors of this work, it must be emphasized that the model presented and tested adapts to variations in terms of the sequence of the mechanisms and basic rules proposed for the design of governance. Although selection and integration of partners appear as the first step for the design as part of the scoping stage, the order of the mechanisms and rules that are part of the initiate stage may be more flexible.

Another point that deserves special attention is related to the participatory process presented in this article. Having observed the enthusiastic participation of the workshop attendees in the Embrapa innovation process, it was essential to design networking based on a participatory approach, with different perspectives generating deep reflection and diverse perspectives.

Although we will focus on the results of the governance model in future articles, at this time (May 2024), the Embrapa Business for Innovation Network has been in operation for around two years. In this short period, an increase in interaction between the science, technology, and innovation teams of Embrapa's research centers was perceived, generating partnership actions focused on open innovation.

Resulting from this, the Embrapa Business for Innovation Network has managed to hold 15 events for the exchange of knowledge between the different Embrapa research centers on topics related to open innovation. Furthermore, the increase in interaction between Embrapa centers has impacted new opportunities for interaction with other actors in the innovation ecosystem, in an open innovation process that is related to the one presented in Figure 1, in which players as innovation engineers, idea connectors, idea explorers, and external sources of knowledge get connected.

Among many important opportunities created as a result, we must emphasize the participation of four Embrapa research centers in the Cerrado Sustainable Soy program, promoted by the Agtech Garage hub, and the organization of the All 4 Food Connection initiative, with the presence of eight Embrapa centers, carried out by the All 4 Food network. Other more specific actions may be mentioned, including the creation of work groups limited to the services provided in the governance of the Embrapa Business for Innovation Network, as presented in Figure 4.

This article hopes to help in understanding the importance of intraorganizational networks in addressing the silo effect in the value generation process in organizations, presenting a model to facilitate the shared development of new governance mechanisms. It is to be hoped that other researchers feel free to systematize the process of designing networks and alliances, with new elements that can help organizations and theoretical advances in academia.

TECHNOLOGICAL-SOCIAL CONTRIBUTION

The silo effect is a social phenomenon that can compromise the functioning of human organizations and their value generation processes. As an object of the study presented in this article, the innovation process demands management actions that allow greater integration between the parties that have internal networks as a vehicle to confront the silo effect.

Some limitations in the results must be emphasized. Firstly, considering that the design is focused on stages 1 (scoping) and 2 (initiating), the key monitoring and review actions presented in phase 3 (implementing), an important part of the decision-making, may be changed. It is therefore necessary, as part of the object of this study, to carry out monitoring studies of the network, making long-term comparisons in order to evaluate real results and dynamics.

Another limitation of this study that deserves special attention concerns the lack of depth in the discussion of the mechanisms and basic rules related to 'distribution of results' and 'decision-making process.' So there is a high probability of these two basic mechanisms and rules being revised in future or at least of there being a need for a clearer level of precision and richer detail in the later stages.

The main contributions of this article are: (1) research on the contributions of network and alliance governance structures to respond to the silo effect in the innovation process of human organizations; (2) collection and identification of the mechanisms and basic rules for the initial stages of building a network or alliance; and (3) application of network design logic in a real case. The three contributions have important socio-technological implications.

In the case of the first contribution, the understanding of the importance of networks as spaces for integration and, of course, as facilitators and catalysts of partnership work points to intraorganizational networks as being important in the strategy for confronting the

silo effect. It must be emphasized that the silo effect is a contemporary phenomenon that impacts organizations of different categories with important implications.

Regarding the second contribution, the authors of this article understand that it is important to instrumentalize the network design process. With this in mind, integration of knowledge produced by different authors enables a deeper reflection on the mechanisms and basic rules for the layout of the governance mechanism of a network.

With regard to the third contribution, this work has been prepared with the intention of making available to the public the theoretical-practical contributions produced by a real experience focused on open innovation in the design process of an internal network. Researchers and professionals may thus be inspired by the work we have carried out and the results achieved.

REFERENCES

Álvarez, G., Pilbeam, C., & Wilding, R. (2010). Nestlé Nespresso AAA sustainable quality program: An investigation into the governance dynamics in a multi-stakeholder supply chain network. *Supply Chain Management, 15*(2), 165-182. https://doi.org/10.1108/13598541011028769.

Andrade, R. J. C. D., Sousa-Filho, J. M. D., Almeida, F. E. B. D., & Câmara, S. F. (2021). Pandemic fights in a network! COVID-19 challenges in northeast Brazil. *Revista de Administração Contemporânea*, *25*(esp.), e200256. https://doi.org/10.1590/1982-7849rac2021200256.en

Arranz, N., & de Arroyabe, J. F. (2007). Governance structures in R&D networks: An analysis in the European context. *Technological Forecasting and Social Change*, *74*(5), 645-662. https://doi.org/10.1016/j.techfore.2006.05.009.

Bambini, M. D., Coltri, P. P., Furtado, A. T., Zullo, J. (2014). Collaborative innovation in agrometeorology: Coordination strategies to develop a monitoring IT system for Brazil. *Journal of technology management & innovation*, *9*(1), 119-130. https://www.alice.cnptia.embrapa.br/handle/doc/987542?locale=en

Barabási, A. L. (2002). *The new science of networks*. Perseus

Barabási, A. L., & Oltvai, Z. N. (2004). Network biology: understanding the cell's functional organization. *Nature Reviews Genetics, 5*(2), 101-113. https://doi.org/10.1038/nrg1272

Bollobás, B. (1998). Random Graphs. In Modern Graph Theory. Graduate Texts in Mathematics (vol. 184). Springer. https://doi.org/10.1007/978-1-4612-0619-4_7

Briody, E. K., & Erickson, K. C. (2014). Success despite the Silos: System-Wide Innovation and Collaboration. International *Journal of Business Anthropology, 5*(1). https://doi.org/10.33423/ijba.v5i1.1141

Bygballe, L. E., & Ingemansson, M. (2014). The logic of innovation in construction. *Industrial Marketing Management, 43*(3), 512-524. https://doi.org/10.1016/j.indmarman.2013.12.019

Chesbrough, H. (2003). The era of open innovation. MIT *Sloan Management Review.* https://edisciplinas.usp.br/pluginfile.php/4294458/mod_resource/content/2/Henry%20Chesbrough%20The%20Era%20of%20Open%20Innovation%202003%20MIT.pdf

Cristofoli, D., & Markovic, J. (2016). How to make public networks really work: A qualitative comparative analysis. *Public Administration*, *94*(1), 89-110. https://doi.org/10.1111/padm.12192

Dhanaraj, C., & Parkhe, A. (2006). Orchestrating innovation networks. *Academy of Management Review*, *31*(3), 659-669. https://doi.org/10.5465/amr.2006.21318923

Dimitratos, P., Lioukas, S., Ibeh, K. I., & Wheeler, C. (2010). Governance mechanisms of small and medium enterprise international partner management. *British Journal of Management, 21*(3), 754-771. https://doi.org/10.1111/j.1467-8551.2008.00620.x

Favarin, A. M., Dias, C. N., Costa Filho, B. A., Figueiredo, S. S. S. de, & Bambini, M. D. (en prensa). Complejidad en el proceso de innovación y el efecto silo. Estudio de caso en un instituto público de investigación. *Cadernos de Ciência e Tecnologia.* In press.

Gardet, E., & Fraiha, S. (2012). Coordination modes established by the hub firm of an innovation network: The case of an SME bearer. *Journal of Small Business Management*, *50*(2), 216- 238. https://www.tandfonline.com/doi/abs/10.1111/j.1540-627X.2012.00351.x

Gardet, E., & Mothe, C. (2011). The dynamics of coordination in innovation networks (Winter 2011). *European Management Review*, *8*(4), 213-229, 2011. https://doi.org/10.1111/j.1740-4762.2011.01020.x

Granovetter, M. S. (1973). The strength of weak ties. American Journal of Sociology, 78(6), 1360-1380. https://doi.org/10.1086/225469

Hanifah, H., Halim, H. A., Ahmad, N. H., & Vafaei-Zadeh, A. (2020). "Can internal factors improve innovation performance via innovation culture in SMEs?", *Benchmarking: An International Journal*, *27*(1), 382-405. https://doi.org/10.1108/BIJ-06-2018-0174

Henttonen, K., Lahikainen, K., & Jauhiainen, T. (2016). Governance mechanisms in multi-party non-profit collaboration. *Public Organization Review*, *16*(1), 1-16. http://dx.doi.org/10.1007/s11115-014-0293-8

Lavikka, R. H., Smeds, R., & Jaatinen, M. (2015). Coordinating collaboration in contractually different complex construction projects. *Supply Chain Management: An International Journal*, *20*(2), 205-217. https://doi.org/10.1108/SCM-10-2014-0331

Mariani, M. M. (2016). Coordination in inter-network co-opetitition: evidence from the tourism sector. *Industrial Marketing Management*, 53, 103-123. https://doi.org/10.1016/j.indmarman.2015.11.015

Monge, P. R., & Contractor, N. S. (2003). *Theories of communication networks*. Oxford University Press.

Owen-Smith, J., & Powell, W. W. (2008). Networks and institutions (pp. 596-623). In *The Sage handbook of organizational institutionalism*. Sage.

Park, S. H., & Ungson, G. R. (2001). Interfirm rivalry and managerial complexity: A conceptual framework of alliance failure. *Organization Science*, 12(1), 37-53.

Pastor-Satorras, R., & Vespignani, A. (2004). Evolution and structure of the Internet: A statistical physics approach. Cambridge University Press

Pereira, C. N., & Castro, C. N. (2020). O Sistema Nacional de Pesquisa Agropecuária e a análise dos investimentos no fundo setorial do agronegócio. *Revista De Economia E Sociologia Rural, 58*(2), e181041. https://doi.org/10.1590/1806-9479.2020.181041

Pérez Andrés, C. (2002). Sobre la metodología cualitativa. *Revista Española de Salud Pública*, 76(5), 373-380.

Quinhões, T.A.T. & Lapão, L.V. (2024). Gestão da Inovação: há ainda um longo caminho a percorrer. *Revista de Administração de Empresas*, 64(1), 1-15. http://dx.doi.org/10.1590/S0034-759020240107x.

Roberts, N. C. (2011). Beyond smokestacks and silos: Open source, Web enabled coordination in organizations and networks. *Public Administration Review, 71*(5), 677-693. https://doi.org/10.1111/j.1540-6210.2011.02406.x

Sanchez-Famoso, V., Maseda, A., & Iturralde, T. (2014). The role of internal social capital inorganisational innovation. An empirical study of family firms. *European Management Journal, 32*(6), 950-962. https://doi.org/10.1016/j.emj.2014.04.006

Schepis, D., Purchase, S., & Butler, B. (2021). Facilitating open innovation processes through network orchestration mechanisms. *Industrial Marketing Management,* 93, 270-280.

Sikandar, H., Haiyat, U., Kohar, A., CorzoPalomo, E.E., GameroHuarcaya, V.K., RamosMeza, C.S., Shabbir, M.S., & Jain, V. (2023). Mapping the Development of Open Innovation Research in Business and Management Field: A Bibliometric Analysis. *Journal of the Knowledge Economy*. 1-23. https://doi.org/10.1007/s13132-023-01280-2

Smith-Doerr, L. & Powell, W. (2005). 17. Networks and economic life. In N. Smelser & R. Swedberg (Ed.), The Handbook of Economic Sociology (pp. 379-402). Princeton University Press. https://doi.org/10.1515/9781400835584.379

Stott, L., & Keatman, T. (2005). *Tools for Exploring Community Engagement in Partnerships*. In Practitioner Note; Building Partnerships for Development in Water and Sanitation (BPD): London, UK. https://www.bpdws.org/web/d/doc_267.pdf?statsHandlerDone=1

Tett, G. (2015). *The silo effect: The peril of expertise and the promise of breaking down barriers*. Simon & Schuster.

Uzzi, B. (1996). The sources and consequences of embeddedness for the economic performance of organizations: The network effect. *American Sociological Review, 61*(4), 674-698. https://doi.org/10.2307/2096399

Uzzi, B. (1997). Social structure and competition in interfirm networks: the paradox of embeddedness. Administrative Science Quarterly, 42(1), 37-69. https://doi.org/10.2307/2393808

Wegner, D., Koetz, C.I., & Wilk, E.O. (2013). Social capital in Brazilian small-firm networks: the influence on business performance. *International Journal of Entrepreneurship and Small Business*, *20*(4), 446–461. http://dx.doi.org/10.1504/IJESB.2013.057201

Whelan, E., Parise, S., De Valk, J., & Aalbers, R. (2011). Creating employee networks that deliver open innovation. *MIT Sloan Management Review*, September 21. https://sloanreview.mit.edu/article/creating-employee-networks-that-deliver-open-innovation/

Yin, R. (2014). *Estudo de Caso - Planejamento e Métodos* (4a ed). Bookman.

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Conflict of Interests

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2nd author: Funding acquisition (lead), Project administration (equal), Conceptualization (equal), Formal analysis (equal), Methodology (equal), Writing – review & editing (equal).

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