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Model for Strategic Management of Technological Innovation in Science and Technology Institutions in the Brazilian Aerospace Sector: A Proposal

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ABSTRACT

Public Science and Technology Institutions (STIs) need to assume and consolidate a proactive role in innovation management to transform knowledge advances into appropriate results for the industrial base. It is required a strategic managerial action aimed at sustaining the sector's ecosystem and guided by the principle of entrepreneurship. Considering the context of STIs in an integrated approach to the technological innovation process, two questions were raised: How to guarantee an architecture and organizational governance that favor entrepreneurial behavior by linking it to the technological innovation strategy in the ecosystem, and how to expand and promote interactions among ecosystem agents, ensuring an environment leading to innovation and the dissemination of the knowledge generated. The proposed managerial model can be applied in any national or international technology-based innovation ecosystem keeping the characteristics of the business environment. The authors used extensive literature research and direct observation to develop ideas and link them to this management practice. The result was a strategic innovation management model for technology-based STIs. It has management instruments that enhance the proactive performance of ecosystem agents and helps them transfer and absorb the developed technologies.

Keywords: Brazilian Aerospace and Defense Sector; Innovation Management; Management; Scientific and Technological Institution.

INTRODUCTION

An essential factor for any scientific and technological institution – STI is to build and consolidate an architecture and organizational governance to expand the capacity to act in the technological innovation process. It is notorious that the process of technological innovation, from the generation to the economic appropriation of R&D results, is complex, difficult, and risky. According to Tigre (2006, p. XIII), it "depends not only on qualifications and technical-financial assets held by the firm but also the institutional environment in which it operates".

The innovation process is altered as a result of the use of new approaches and organizational technologies that allow the acceleration of the manipulation of information and ideas in the economic, technological, and social understanding of the business environment (Dodgson *et al.* 2014).

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This contingency orientation emphasizes the open innovation approaches adopted by public and private institutions (Bigliardi *et al.* 2020; Chesbrough 2006; Mirza *et al.* 2022; OECD 2008).

In the context of the Brazilian technological innovation legal framework, the STIs are directed to adopt these approaches to expand the capacity of the innovation ecosystem to support the needs and interests of the main users of the RD&I activities of these STIs.

The differential of the proposed model for managing technological innovation in public STIs lies in the structuring of architecture and governance capable of creating and expanding entrepreneurial behavior, linking it to the process of strategic management of technological innovation in STIs, respecting the particularities of the base industry and the missions of these STIs in the sector's technological innovation ecosystem.

This work focuses on the technological innovation process of public science and technology institutions in the Brazilian Aerospace and Defense sector. This focus is justified by the relevant and notorious role that these STIs play in expanding technological capabilities for the development and support of this sector in Brazil (Brick 2019).

The managerial model proposed here can be applied to any national or international technology-based innovation ecosystem keeping the characteristics of the institutions and legislation of each country.

The dynamics of the technological innovation process in the Aerospace and Defense sectoral system are determined by the peculiarities of a group of factors, some of which are dealt with in this work.

This dynamic was analyzed from the understanding of an integrated approach and the Brazilian context in which STIs operate, which distinguishes this system, such as the market structure, technological capacity, the strategic condition imposed by producing nations and companies, in addition to the very organizational particularities of these STIs.

In this scope, there are two basic questions guiding this work: a) How to guarantee an architecture and organizational governance that favors entrepreneurial behavior, linking it to the process of strategic management of technological innovation in the ecosystem and that helps in the sustainable growth of the aerospace industrial base and Brazilian Defense, and b) How to expand and promote interactions between STIs and agents in the Brazilian Aerospace and Defense innovation sectoral system, ensuring an environment conducive to innovation and the dissemination of generated knowledge.

The complexity presented by the object under study implies a high level of reflection regarding the business environment and managerial practices involved in the strategic management process to guide a proactive, enterprising performance in the technological innovation ecosystem of the sector in focus.

This work was based on studies in economics of innovation, sociology of innovation, innovation management, R&D management, alliance management, and technology transfer, among others. Understanding these fundamentals, searching for possible solutions to the questions raised, allowed the development of a conceptual model of strategic management of technological innovation in the Brazilian Aerospace ecosystem and Defense sector.

METHODS

The complexity presented by the object of the study implies a high level of reflection on the business environment and management practices involved in the strategic management process to guide proactive action in the technological innovation ecosystem.

According to Tidd *et al.* (2008):

> If we understand only part of the innovation process, the practices we adopt to manage it will also be likely to be only partially useful (p. 85).
>
> One of the biggest problems in innovation management is that we need to understand a set of complex, uncertain and high risky phenomena (p. 96).

Saunders *et al.* (2009, p. 6) argue that the management research characteristic is its transdisciplinary nature. They also state that "another characteristic of management research is the belief that it must be able to develop ideas and relate them to practice".

The dynamics of the technological innovation process in the Aerospace and Defense sectoral system are determined by the peculiarities of a group of factors, some of which are dealt within this work.

The dynamics were analyzed from the understanding of an integrated approach and the Brazilian context in which the STIs operate, which distinguishes this system, such as the market structure, the technological capacity, and the strategic condition imposed by producing nations and companies, among others.

The methodological procedure used in this work is described based on these considerations.

This is an exploratory and applied research (Gil 2017; Severino 2013). As quoted by Matias-Pereira (2019, p. 4), in applied research "the acquired knowledge is used for practical application and aimed at solving concrete problems of modern life".

The Design Science Research – DSR approach was adopted. This approach has been used more frequently in administration – Strategies, Organizational Development, Business Models, Finance, RD&I, among others Production Engineering, IT and Information Systems, and related areas. It is a problem-solving approach.

Dresch *et al.* (2015a, p. 95) stated that DSR "is the most indicated research method when the study objective is to design and develop artifacts, as well as prescriptive solutions, whether the environment is real or not" The researcher's role in the process is to understand a problem and find possible solutions to it.

The justification for adopting the DSR as a methodology in this work is based on the following aspects:

- The DSR is suitable for seeking answers to the questions raised, of a prescriptive nature;
- The purpose of the research is to propose a model conducive to the proactive and strategic management of the technological innovation process in a technology-based ecosystem;
- The research is based on a theoretical-conceptual approach to developing this model and its relationship with managerial practice.

Table 1 shows the alignment of this work with the adopted DSR methodology.

Table 1. General alignment of this work with the adopted DSR methodology.

Element	Design Science Research	This work	Alignment
Objectives	Development of artifacts that allows satisfactory solutions to practical problems	Develop a managerial model conductive to proactive and strategic management of the technological innovation process of technology-based public ICTs	Yes
	Prescribe and Design	Prescribe and Design	Yes
Main activities	Define the problem, follow, develop, evaluate, conclude	- Understanding of the ICT innovation ecosystem; - Definition of expected results; - Evaluation; - Final considerations.	Yes
Results	Artifacts (Constructs, models, methods, instantiations) and theory Improvement	Management model	Yes
Type of Knowledge	How things should be	How the management could be	Yes
Empirical Basis	Not Required	Technical requirements of professionals for contextualization and implementation	Yes
Evaluation of Results	Applications, simulations, experiments	Analysis of managerial performance with a focus on the strategic management of technological innovation in ICTs	Yes
Implementation	Not Required	Professionals with technical expertise in strategic management of technological innovation in technology-base sectors	Yes
Approach	Qualitative and-or Quantitative	Qualitative	Yes
Specificity	Generalizable to a certain class of problems	Generalizable with limitations	Partial

Source: Prepared by the authors based on Dresch *et al.* (2015b).

In the construction of answers to the questions raised in this work, we used the steps presented by Vaishnavi and Kuechler (2004, p. 11–13):

- Awareness of the problem – The authors started from the motivation to seek an architecture and organizational governance, with management instruments that help mitigate risks and uncertainties intrinsic to the process, for a proactive role in the management of technological innovation in the innovation ecosystem of the Aerospace sector and Brazilian Defense. This motivation arose from the authors' experience as professionals in technological innovation management in public STI in the mentioned sector, and through the study of the literature in areas related to the theme, seeking reflection on theory and practice in this business ecosystem.
- Suggestions – The authors sought to structure a proposal for an organizational model that would support the framework of managerial disciplines appropriate for this proactive management of technological innovation in the ecosystem in focus.
- Development of the artifact – Several management models were developed, seeking an organizational architecture that contemplated a system aimed at strategic management of technological innovation in this ecosystem. We arrived at a configuration presented as a proposed model for the strategic management of technological innovation in the innovation ecosystem.
- Evaluation of the artifact (model) – The managerial model proposed was qualitatively evaluated based on the theoretical foundation studied and following the descriptive method, as explained by Hevner *et al.* (2004, p. 86). For these authors, the descriptive evaluation aims to demonstrate the usefulness of the developed model. In the descriptive method, existing arguments in literature can be applied to analyze, build and demonstrate the model usefulness.

RESULTS AND DISCUSSION

The proposed management model was developed from the process-based technological innovation management comprehension (Dodgson *et al.* 2014; OECD 2008; Tidd *et al.* 2008; Tigre 2006). According to Dodgson *et al.* (2014, p. 4), "the study of innovation management is based on understanding the sources, nature, and results of innovation and the economic, technological, and social context in which it occurs"

The proposed model, guided by the approach of open innovation and the principle of entrepreneurship, brings together attributes that combine processes and management disciplines aimed at:

- Perception of internal and external factors to the ecosystem in focus that condition its performance;
- Application of competitive intelligence instruments for the formulation and generation of technological routes (TRM);
- Application of managerial instruments to mitigate the existing risks in the transition between the development of technologies until the successful placement of technological solutions in the market.

Perception of internal and external factors to the ecosystem in focus that condition its performance

This perception is characterized by the systemic view of intra and extra-organizational elements that contribute to the strategic orientation of the innovation management process and helps the business environment with qualitative interpretation. Three constraints are listed: Structural, Normative, and Fostering, and the productive system and the market.

Structural constraints refer to agents that form scientific and technological skills (STI, teaching institutions, and agents that promote the culture of innovation, entrepreneurship, and the competitiveness of companies that are part of the ecosystem). Understanding the actions, directions, and results obtained by these agents subsidizes the innovation management process about existing technological capabilities and those necessary to expand and sustain the productive competitiveness of companies.

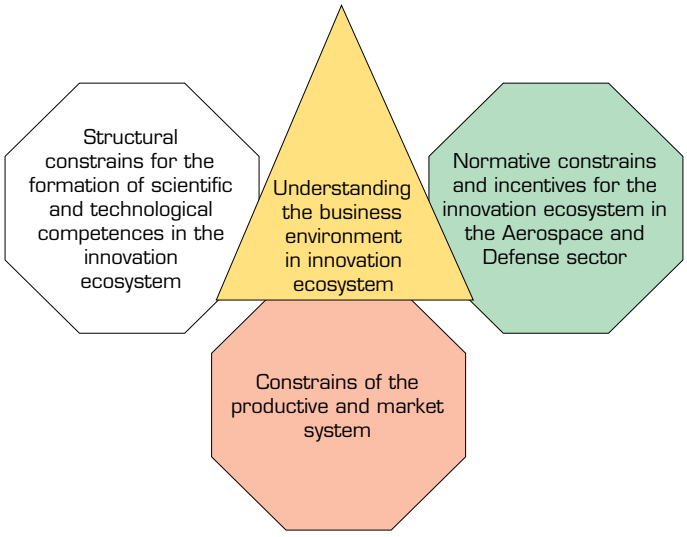
Regarding normative constraints, there is a range of regulations, policies, and guidelines that ecosystem agents must respect and follow, using them as guidelines for the objectives to be pursued by this ecosystem. Understanding these constraints positively affects management in the sense of eliminating or reducing insecurities about the possibilities and legal opportunities that limit action in the process of managing technological innovation.

These normative constraints include activities that are considered to support the innovation management process in STIs. They are contextual constraints related to the most appropriate means for the economic and strategic appropriation of the knowledge obtained from R&D activities and transferring technological processes to the productive sector. The management of intellectual assets is considered a strategic factor for technology-based companies, both as a mechanism for maintaining and

expanding competitive advantages and for economic appropriation of RD&I results. It involves legal and operational specificities in obtaining and using IP that must be considered. There are also legal aspects to the process of transferring appropriate Technologies.

Conditioning the productive sector and the market are the needs, interests, and technological absorption capabilities of the Brazilian Aerospace and Defense industrial base. There is also the investment capacity for developing, producing, and marketing these technologies.

Figure 1 represents the dynamics of the perception of the presented conditioning factors.



Source: Elaborated by the authors.

Figure 1. Dynamics of the perception of the presented conditioning factors.

It should be noted that these conditions are interrelated and positively or negatively affect managerial performance in the process of strategic management of technological innovation in the sector in focus.

Application of competitive intelligence instruments for the formulation and generation of technological routes

Competitive intelligence is conducted to answer the question of who is doing what and in which direction for technology roadmap formulation and generation (TRM).

Prospective studies are important sources in the formulation of technological strategies by providing the necessary basis for the consensual articulation of future technological attractiveness. Understanding the Scenario subsidizes the purposeful generation of RD&I projects that can effectively meet the needs and opportunities verified for use by the agents involved in the innovation ecosystem of the Brazilian Aerospace and Defense sector.

These studies in Science, Technology and Innovation do not refer to prediction, but to surveys, investigations regarding a certain subject, indicating patterns in the behavior of the analyzed variables, opportunities and threats to technological development.

They try to systematically explore and map the developments in Science and Technology in search of possible alternatives for the future. They are always carried out and analyzed from a systemic perspective due to the complexity of the structure of relationships between the elements studied.

In the proposed model, the competitive intelligence instruments are directed towards the construction of scenarios aimed at understanding technological advances and formulating technological routes (TRM) that subsidize the decision-making process for the consensual and purposeful articulation of RD&I guiding the agents regarding the search for technological solutions to be made available to the market.

It is understood that the generation of technological roadmaps aligned with the needs and interests of the ecosystem agents enables an organized action and with a driving effect for the development and application of technologies in the Brazilian Aerospace and Defense sector.

Application of management instruments to mitigate existing risks in the transition between technology development and the successful placement of technological solutions on the market

This model lists management instruments used by STIs that can be treated to help mitigate the risks inherent in the transition between discovering opportunities and developing products. The literature is called "Death Valley". According to Markham (2002, p. 31) "The Valley of Death" is the gap between the technical invention or market recognition of an idea and the efforts to commercialize it".

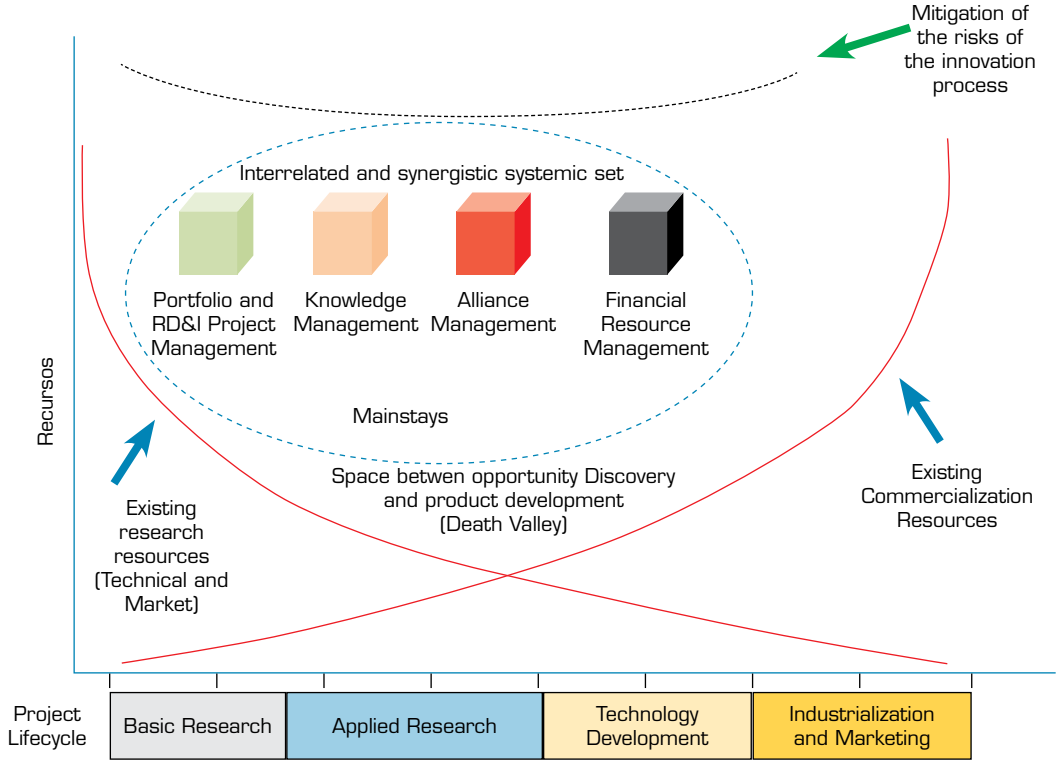
The intentional application of these instruments focusing on technology transfer is the objective of this proposed framework. It is based on the characteristics and activities of the STIs' RD&I, pre-development activities (Basic Research, Applied Research, Technological Development), and activities of the technology-based productive sector (industrialization of new products and technological processes arising from R&D).

It is not an exhaustive, complete managerial framework; other management instruments can be incorporated and used for this purpose depending on the focus and strategic needs of the agents.

Proactive action in this transition process is at the heart of the entire model for the effective development and availability of Technology to the market. It is an extremely critical factor for the technological innovation management process, which requires managerial actions to promote the transition.

Risk mitigation in the transition from R&D to industrialization is vital for any industrial organization and even for STIs that develop RD&I projects. It should be noted that the insertion of a new Technology in the market is a "collective game", both in the STIs and in conjunction with the agents of the entrepreneurial ecosystem.

Figure 2 presents the management framework for mitigating the risks associated with the transition between phases of the project's life cycle related to the concept of the Death Valley.



Source: Elaborated by the authors.

Figure 2. Management framework for mitigating the risks associated with the transition between the phases of the project life cycle related to the valley of death concept.

The disciplines are:

RD&I Portfolio and Project Management

It is the key activity in the strategic process of technological innovation. It is not an isolated activity but an integrated set aimed at technological development. The process is complex, extremely peculiar and largely affected by the innovation ecosystem where STIs are inserted. Using appropriate techniques and tools for context analysis is a valuable discipline to help mitigate risks in the technological innovation process.

Portfolio management is a dynamic process to provide information about various questions that are essential to the decision-making about the composition and scope of the areas of knowledge that STIs are directing their technological capabilities.

According to the PMI (2021, p. 232), a portfolio is defined as "projects, programs, subsidiary portfolios and operations managed as a group to achieve strategic objectives".

Project management is defined as (PMI 2021, p. 24), "the application of knowledge, skills, tools and techniques to project activities to meet project requirements".

It is implicit in these definitions that project management practices are structured based on the technical skills of each organization and are adapted and adjusted according to the characteristics of organizations and projects. It also implies the execution of projects efficiently and effectively.

Management of RD&I projects in the context of this work refers to the use of a set of management instruments for the exploration, ordering, coordination and execution of the research necessary for the development of "technological solutions" (products and processes) demanded by users or made available to them.

From the analysis of these instruments, it is possible to decide in which RD&I projects to invest financial resources in the identification of gaps in technologies and areas of knowledge essential for obtaining strategic products and processes, which research areas to prioritize, what impacts the set of technologies in the portfolio have on strategic objectives, which projects to complete. It is also possible to understand the technological capabilities mastered.

Knowledge management (KM)

In the process of strategic management of technological innovation, RD&I management must be guided by implementing methods that stimulate the generation of ideas and proposals for RD&I projects aimed at developing skills and technologies that support the industrial base of the Brazilian Aerospace and Defense sector. KM is a management model that incorporates these ways of generating ideas. These authors consider KM a support to mitigate risks in the innovation process based on the understanding given by the PMBOK.

It is stated that: "From an organizational perspective, knowledge management involves ensuring that the skills, experiences, and expertise of the project team and other stakeholders are used before, during and after the project" (PMI 2017, p. 100).

Regarding the use of management tools and techniques, it is mentioned that the appropriateness of use "depends on the nature of the project and the level of diversity (including the diversity of disciplines) among the team members" (PMI 2017, p. 102).

KM literature in general has highlighted basic activities for knowledge management (CEN 2004; ISO 2018). Among them are:

- Identification and capture of knowledge

KM should be directed towards knowledge considered strategic and that makes the difference for the competitiveness of the institutions. The identification of existing and missing knowledge is essential to support decision-making on capturing new knowledge. Thus, it is necessary to have a continuous mapping of organizational competences.

- Knowledge Generation

There are many ways and organizational initiatives aimed at generating knowledge. This generation is continuous and carried out through the collective construction of knowledge resulting from social interaction. In relation to the industry, it is translated by developing technological products and services.

Organizational learning depends on practices and routines of interaction patterns inside and outside the organization and, mainly, on the ability to mobilize individual knowledge and promote this interaction.

- The generation of knowledge focused on the RD&I process can be optimized, for example, by encouraging the creation of groups of specialists, commonly called "communities of practice," which are self-organized groups to share their common R&D expertise and interests. These communities can be formed by professionals from inside and outside the institutions.
- Knowledge Accumulation

Knowledge needs to be incorporated into organizations. Many organizational actions are wrongly structured with the purpose of accumulating knowledge through information technologies, disregarding that they deal only with instruments for storing and distributing information. IT must be understood as a "means" to make it easier for professionals to handle information needed for their activities. Actions aimed at constantly training professionals are necessary to expand the ability to absorb knowledge. Furthermore, as mentioned by CEN (2004, p. 10), "knowledge can be 'stored' in the routines of the team or organization, even without having been explicitly described [...]. As long as these people and teams remain accessible, it can be said that their knowledge is 'memorized' by the organization and available for (re)use".

- Knowledge Dissemination

The spread of necessary and strategic useful knowledge to maintain organizational skills is not a trivial task. It is essential to identify the sources of institutionally relevant knowledge to make them available to professionals.

Information technologies should be employed to disseminate and transfer knowledge, but alone it does not guarantee the effectiveness of the process. Its function is to amplify and accelerate the process.

Organizations should value knowledge sharing, helping and promoting an institutional and behavioral culture that encourages organizational learning.

Alliance Management

The basis of the open innovation approach is the synergy between organizations in the search of technological solutions to meet the needs of the market and society. These synergies are important for providing complementarity organizational skills; no organization has competencies in all areas of knowledge, whether in organizational disciplines or in mastering some stage of the technological development of products or processes that the organization is working on. As part of the managerial framework for mitigating the risks inherent in the innovation process, alliance management enables R&D and the ecosystem's productive sector agents to mobilize their skills in a coordinated manner to improve and enhance R&D capacity and the transfer of technological solutions built to meet the needs and interests of the productive sector and market. In this sense, alliances serve as flows of information and knowledge between the parties.

Teece (1992, p. 19) defines a strategic alliance as "a constellation of agreements characterized by the commitment of two or more partner firms to achieve a common objective, involving the pooling of resources and activities [...] A strategic alliance denotes some degree of strategic and operational coordination".

The management of strategic alliances requires many skills and high competences due to the complexities and uncertainties involved in this activity, and it must always be based on mutual trust between the various partners of the innovation ecosystem, in addition to the continuous effort to maintain the strategic objectives agreed.

Therefore, alliance management must be treated as a dynamic process involving the particularities and interests of each partner and organization, requiring punctual and specific management actions.

Financial Resources Management

The volume of financial resources actively influences the RD&I process and is also one of the most critical factors to help mitigate risks in the technological innovation process. The State has a preponderant role in its promotion (Mazzucato 2013). In Brazil, the financing of this process is traditionally associated with public resources. This is mainly due to the high degree of risk in RD&I activities.

According to Negri (2018, p. 107), Brazil, in the last two decades, "undertook a series of measures aimed at strengthening the scientific, technological and innovation capacity in the country" According to the author, these measures include direct financial support for investments in research at universities, research centers and companies, such as credits for business investments in R&D, tax incentives and regulatory measures.

Concerning the private agents of the productive sector in the innovation ecosystem, there are varied sources of resources with specific objectives and conditions for each need. It all depends on the type of technology, the amount required, the guarantees offered by interested parties, and the characteristics of the projects, among others.

The decision on which will be the best financing instrument is not an ordinary activity; it requires a management capable of mobilizing the institution and interacting with its innovation ecosystem for the understanding and effective use of the different instruments available at each moment of the innovative process, with the adoption of managerial techniques of strategic planning, incorporating coordinated and integrated decisions with the actors of the ecosystem.

Active participation in the entrepreneurial ecosystem

From the perspective of open innovation, the proposed model considers the insertion of STIs in the innovation ecosystem with a present and active participation.

Technological development may not reach the market or be accepted by it. It makes it crucial to have an important innovation success factor. It is about knowing the market opportunities and how to use it in the business model. This knowledge is guided by continuous interaction with agents with entrepreneurial capacity to successfully assist the introduction of the product or process it in the market (technological innovation).

The ecosystem approach is complementary to innovation systems, highlighting the nature of interrelations between agents, mainly by directing the focus of innovation challenges to the business environment and system members. One of the immediate benefits of this positioning refers to the fulfillment of the objective, of the Innovation Law nº 10.973/04 (Brazil 2004), of encouraging interactions between STIs and the productive sector and thus promoting the development of Brazilian S&T.

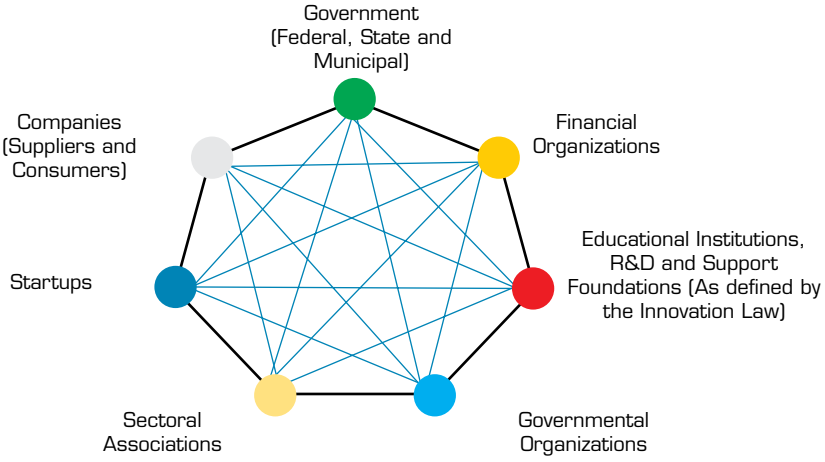
In the metropolitan region of Vale do Paraíba, the location of the main STIs in the Brazilian Aerospace and Defense sector, the Technological Park of São José dos Campos – PqTec can assume the role of a hub organization, with responsibility for orchestrating the Brazilian Aerospace and Defense innovation ecosystem.

The term "orchestration" is used in the literature on innovation ecosystems. For Dhanaraj and Parkhie (2006, p. 659), "it is the set of deliberate and intentional actions carried out by the central organization that seeks to create and extract value from the network".

These attributions refer to the political action of leadership in the sense of aggregating the respective agents to create broad and continuous interrelationships, and a joint search for structuring mechanisms for the dissemination and application of institutional capacities to develop technological solutions desired by the Brazilian industrial base.

It is not possible to copy successful models from another ecosystem. The architecture of the process depends on factors affected by political circumstances and economic and social issues that transcend the interests of agents directly involved in the ecosystem governance. It is up to these agents to define their common goals and move forward.

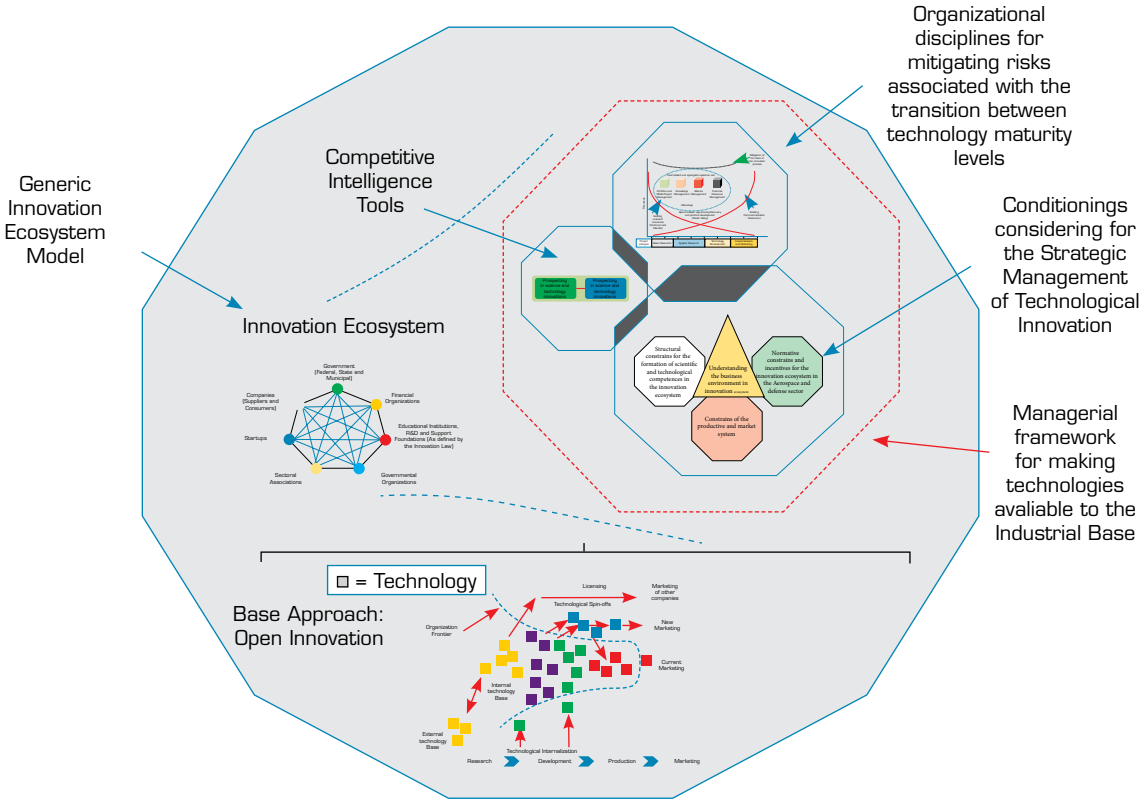
Figure 3 represents the business ecosystem, graphically demonstrating the interaction dynamics of the various agents in the system.



Source: Elaborated by the authors based on the generic model of Isenberg (2010).

Figure 3. Entrepreneurial ecosystem.

Figure 4 presents the proposed model with approaches to provide an integrated vision and perception for strategically managing innovation in the Brazilian Aerospace and Defense ecosystem.



Source: Elaborated by the authors.

Figure 4. Framework with the approaches presented for the Strategic Management of Technological Innovation.

CONCLUSIONS

Based on the studies carried out, it was possible to build a model for the strategic management of technological innovation aimed at expanding the performance capacity of public STIs, favoring entrepreneurial behavior, promoting interactions between these STIs and the agents of the Brazilian Aerospace and Defense sector ecosystem and ensuring an environment conducive to innovation and the dissemination of the technical knowledge generated.

It is observed that the objective of the STIs should not be only in the incorporation by the companies of the technology obtained, but mainly in creating technical conditions for the sustained development of the companies. It is the main purpose of Innovation Law nº 10.973/04 mentioned in the work.

It is considered that the managerial framework presented, organized and systemically articulated, favors the proactive performance of STIs in the ecosystem innovation and induces the development of dynamic capacities and technological absorption in the business environment. It is also considered that the model makes it possible to integrate the institutional dynamics of STI R&D management with the competitive dynamics of the productive base, bringing together the agents' distinctive competences to expand the technological response capacity to the sector interests and needs.

Using the Design Science Research approach, the management model was researched, analyzed and constructed. The performance evaluation of the model was carried out. In this context, the management model evaluation was carried out based on the quality

attributes, with adaptation for the purpose of this work, a pragmatic validation of the usefulness and applicability of the model. The attributes considered were: Functionality, Coherence, Usability and Suitability.

- Functionality – In this regard, it was evaluated that, supported by the systemic, interrelated concept, the set of organizational disciplines presented helps in the process of strategic management of technological innovation by enabling deliberate actions in the decision-making process necessary to mitigate the inherent risks and uncertainties, including instruments for managing R&D and managerial tools to assist in the provision of technological solutions achieved by the productive sector.
- Coherence – There is a strong coherence between the proposed model and the objectives of the STIs to help the emergence of technological solutions, the hub and the orchestrator agent to support companies in incorporating them into products and processes in the market (innovation).

It is also coherent for enabling the expansion of synergy between the agents of the innovation ecosystem, following the precepts of Brazilian economic development and innovation policies to stimulate an environment favorable to innovation, cooperation, technology transfer, industrial competitiveness and national technological training, leading to an increase in the technological content of products and services of interest to the Brazilian Aerospace and Defense sector.

- Usability (ease of use of the management instruments contained in the proposed model) – It is verified that they are common instruments for the science and technology management of STIs and for the agents' performance in the innovation ecosystem. The authors sought a set of ordinary management disciplines and techniques among organizational agents. They are already part of the activities related to science and technology management. The differential proposed in this model refers to the deliberate search for a performance focused on the process of strategic management of technological innovation, aiming to make research results and technological solutions achieved available to the productive sector based on the strategic understanding of the business environment in the Brazilian Aerospace and Defense sector.
- Suitability – This architecture is suitable for promoting the necessary creation of shared value, with the guidance of R&D activities aimed at application in order to meet the needs and interests of the agents of the innovation ecosystem of the sector in focus and organizational sustainability (Azevedo and Silveira 2011).

A relevant factor of this model refers to the possibility of agents responsible for R&D and production sharing risks and exploring complementarities of assets (organizational capabilities) using multiple forms of cooperation.

It concludes by emphasizing Tigre's (2006, p. vii) argument that the generation and appropriation of innovations is a complex process that depends not only on the qualifications and technical-financial resources held by the firm, but also on the institutional environment in which it operates and the power of negotiation with suppliers and customers.

It should be noted that the general objective of the work was to present a proposal for a conceptual model of strategic management of technological innovation in a technology-based sector such as Brazilian Aerospace and Defense. Implementation is not in scope, it can be done in future researches.

CONFLICT OF INTEREST

Nothing to declare.

AUTHOR CONTRIBUTIONS

Conceptualization: Brandão Neto N; **Formal analysis:** Melo FCL; **Research:** Brandão Neto N and Leite BRA; **Methodology:** Brandão Neto N and Leite BRA; **Project administration:** Brandão Neto N; **Supervision:** Melo FCL; **Validation:** Melo FCL; **Visualization**: Brandão Neto N and Leite BRA; **Writing - Preparation of original draft:** Brandão Neto N and Leite BRA; **Writing - Proofreading and editing:** Brandão Neto N and Leite BRA.

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REFERENCES

Azevedo AMM, Silveira MA (2011) Gestão da Sustentabilidade Organizacional: Desenvolvimento de Ecossistemas Colaborativos. Campinas: CTI. [accessed Jan 25 2023]. https://www1.cti.gov.br/sites/default/files//images/pdf/publicacoes/livro_1.pdf

Bigliardi B, Ferraro G, Filippelli S, Galati F (2020) The influence of open Innovation on firm performance. Int J Eng Bus Manag 12:1-14. https://doi.org/10.1177/1847979020969545

Brazil (2004) Lei nº 10.973, de 2 de dezembro de 2004. Dispõe sobre incentivos à inovação e à pesquisa científica e tecnológica no ambiente produtivo e dá outras providências. [accessed Dec 18 2022]. http://www.planalto.gov.br/ccivil_03/_ato2004-2006/2004/lei/l10.973.htm

Brick ES (2019) A conceptual framework for defense logistics. Gest Prod 26(4): e4062. https://doi.org/10.1590/0104-530x4062-19

[CEN] Comité Européen de Normalisation (2004) European Guide to good Practice in Knowledge Management – Part 1: Knowledge Management Framework. CWA 14924-1. Bruxelas: CEN. [accessed Oct 10 2022]. http://michel.grundstein.pagesperso-orange.fr/References/CEN_Final_Publication_0403/CWA14924_01_2004_Mar.pdf.

Chesbrough HW (2006) Open Business Models: How to Thrive in the New Innovation Landscape. Boston: Harvard Business School Press.

Negri F (2018) Novos caminhos para a inovação no Brasil. Washington: Wilson Center.

Dhanaraj C, Parkie A (2006) Orchestrating Innovation Networks. Acad Manage Rev 31(3):659-669. https://doi.org/10.5465/amr.2006.21318923

Dodgson M, Gann DM, Phillips N (2014) The Oxford Handbook of Innovation Management. United Kingdom: Oxford University Press. https://doi.org/10.1093/oxfordhb/9780199694945.001.0001

Dresch, A, Lacerda DP, Antunes Junior JAV (2015a) Design Science Research: método de pesquisa para avanço da ciência e tecnologia. Porto Alegre: Bookman Editora.

Dresch A, Lacerda DP, Miguel PAC (2015b) Uma Análise Distintiva entre o Estudo de Caso, A Pesquisa-Ação e a Design Science Research. Rev Bras Gest Neg 17(56):1116-1133. https://doi.org/10.7819/rbgn.v17i56.2069

Gil AC (2017) Como elaborar projetos de pesquisa. São Paulo: Atlas.

Hevner AR, March ST, Park J, Ram S (2004) Design Science in information systems research. MIS Quarterly 28(1):75-105. https://doi.org/10.2307/25148625

Isenberg D (2010) The Entrepreneurship Ecosystem Strategy as a New Paradigm for Economic Policy: Principles for Cultivating Entrepreneurship. The Babson Entrepreneurship Ecosystem Project.

[ISO] International Organization for Standardization (2018) ISO 30401:2018. Knowledge management systems: Requirements. Geneva: ISO.

Markham SK (2002) Moving technologies from lab to market. Research-technology management 45(6):31-42. https://doi.org/10.1080/08956308.2002.11671531

Matias-Pereira J (2019) Manual de metodologia da pesquisa científica. São Paulo: Atlas.

Mazzucato M (2013) The entrepreneurial State: debunking public vs. private sector myths. London: Anthem press.

Mirza S, Mahmood A, Waqar H (2022) The interplay of open innovation and strategic innovation: Unpacking the role of organizational learning ability and absorptive capacity. Int J Eng Bus Manag 14. https://doi.org/10.1177/18479790211069745

[OECD] Organization for Economic Co-operation and Development (2008) Open innovation in global networks. Report. New York: OECD.

[PMI] Project Management Institute (2017) Um guia do Conhecimento em Gerenciamento de Projetos (Guia PMBOK). Newtown Square: Project Management Institute.

[PMI] Project Management Institute (2021) Um Guia para o Conjunto de Conhecimentos em Gerenciamento de Projetos (Guia PMBOK). Newtown Square: Project Management Institute.

Saunders M, Lewis P, Thornhill A (2009) Research methods for business students. England: Pearson Education Limited.

Severino AJ (2013) Metodologia do trabalho científico. São Paulo: Cortez.

Teece DJ (1992) Competition, cooperation, and innovation Organizational arrangements for regimes of rapid Technological progress. J Econ Behav Organ 18(1):1-25. https://doi.org/10.1016/0167-2681(92)90050-L

Tidd J, Bessant J, Pavitt K (2008) Gestão da Inovação. Porto Alegre: Bookman.

Tigre PB (2006) Gestão da Inovação: A economia da Tecnologia do Brasil. Rio de Janeiro: Elsevier.

Vaishnavi V, Kuechler B (2004) Design Science Research in Information Systems. [accessed Sep 19 2022]. http://www.desrist.org/design-research-in-information-systems/