Strengthening The Innovation Management: Insights From the Stage-Gates Model

Trajano Augustus Tavares Quinhoes[1], Luís Velez Lapão[2]

Abstract
This study explores a more pragmatic innovation management system (IMS), based on the Stage Gates Model developed by Cooper and the philosophy of the five Fs. It required extensive bibliographic research, which was carried out in the scientific bases of Web of Science, Scopus, EBSCO and google scholar, and also used the snowball technique. The System is a wide platform, subdivided in four processes: opportunity identification; opportunity selection and prioritization stage; implementation and protection of opportunities; and process and metrics evaluation. Contributions from other authors and more knowledge from management were also included, to strengthen innovation management capacities. The proposed model reflects the current generation of innovation research, based on the theory of ecosystems and the Total Innovation Management (TIM) perspective, and the most recent research on innovation management systems, which are dedicated to integrated models, networking, more regularity in projects evaluation, and parallelism and high functional integration.

Keywords: Innovation; Innovation Management; Innovation Management System; RD&I Management; Organizational Innovation; knowledge management

Submitted: May 17th, 2023 / Approved: July 10th, 2023

1. Introduction

The understanding of the role of innovation has changed in recent decades. It is no longer perceived as a linear and a national process, but as a complex and dynamic endeavor within an ecosystem with a diversity of players, interacting in different levels, in a progressively global context (Schee genannt Halfmann et al., 2019). Innovation in the 21st century is a multiplayer game, and perhaps it is the largest shift in the understanding of innovation. It must be strategically planned and guided by the organization´s leadership, and it should happen interacting very closely with customers, suppliers, workers, research institutions, government, and even with rivals. Innovation is in its 'fifth generation'[1] and became an essential contemporary business procedure (Mir & Casadesus, 2011). It results from a rich and diverse network connections, with intense share of information and support by communication technologies (Callaghan, 2019). The generation of innovations is in a new science era, conceptualized as networked science, with open collaborations and technologically enabled potentialities (Nielsen, 2012).

Another belief is that innovations in businesses activities are the result of methodical investments (not always financial) and efforts made in this direction (Salerno et al, 2010). Successful inventions generally result from a deliberate and intentional search for these possibilities (Kruger et al., 2019). Managing innovation is not easy, it is like trying to hit a "shifting target" (Bessant & Phillips, 2013). This process must be carried out cumulatively and holistically, as a learning process, and not just strengthening skills in specific areas. This paper assumes that innovations can be the result of managerial enterprise and a planned search and deliberated efforts, not just a flash of genius.

Innovation management comprises the systematic use of mechanisms to plan, organize, lead, and coordinate the organization's resources and competences to generate innovations in line with the company's strategies (Vilha, 2010). In a more processual perspective, innovation management is a "mechanism that allows to shape the innovation process, facilitating companies to generate new ideas, practices and products in a systematic way (Pinheiro, 2018), producing a positive effect of innovation on the performance of companies" (Melendez et al., 2019, p. 81). To be successful, innovation management must involve several hierarchical and knowledge levels, and permeate the entire organization (Zen et al, 2017). The literature on innovation management, connects management with innovation strategy, crucial to the survival and achievement of organizations' longer-term objectives (Espinosa-Cristia, 2019).

Formal management of innovation processes is not yet a common practice (Kruger et al., 2019). For many companies, innovation management is usually carried out on an ad hoc rather than systematic basis (Tidd et al, 2005). Organizational managers know that innovation is essential, but few have the experience to manage creativity and innovation in this environment (Riederer et al, 2005). This can be explained by the lack of understanding about what innovation is, in a more entrepreneurial sense, and the resistance to establishing a more formal, organized, and effective procedure for managing innovation due to a false assumption that discipline and creativity are trade-offs

[1] Five generations of innovation processes were recognized (Rothwell, 1992), in order: the linear model (technology push), the reverse linear model (demand pull) and the coupling model, (combined model), which are linear; and the model of interactions in chain (or parallel model) and the systemic of innovation (systems integration), that are interactive models. Innovations, in the 'fifth generation', occurs with several actors inserted in a system of networks and relationships.

(1) Oswaldo Cruz Foundation – Fiocruz, Vice Presidency of Health Innovation and Production – VPPIS, Rio de Janeiro, Brazil
(2) UNIDEMI Research Center/FCT, Universidade Nova de Lisboa (UNL), Lisbon, Portugal
Corresponding author: trajano.quinhoes@fiocruz.br

(Coutinho et al., 2006). Tidd et al (2005) add that there are new routines to be learned, which is difficult, requires time and money to try new things, makes daily work difficult, disrupts organizational arrangements and power structures, and requires efforts to acquire and use new skills. Not surprisingly, most companies are reluctant learners. But there are exceptions, as Google, which successfully developed a specific framework to push for innovation of its portfolio (Steiber & Alänge, 2013).

The literature on innovation sometimes uses knowledge, innovation, and ideation processes, mutually (Kruger et al., 2019). Knowledge is an input for innovation and can be a result of the ideation process. There are many innovation methods available to ideas generation or creative problem solving, like Creative Problem Solving (CPS), lean startup methodology, Design Science Research Methodology (DSRM), innovation mapping, hackathons and others. Kruger (2019) mapped over than a hundred creative techniques, mostly useful for finding new ideas and concepts, solutions to problems with divergent thoughts. Innovation management also should not be confused with innovation management tools (IMT), which are a comprehensive set of tools, techniques and methodologies that support the innovation process in organizations (Hidalgo & Albors, 2008). There is a wide range of IMTs. According to Hidalgo & Albors (2008), the most frequently employed were: project management (82%), business plan development (67%), corporate intranets (66%), and benchmarking (60%). For 34% of the consultancy firms which made part of the research, only few IMT are sufficiently defined to be used successfully (Hidalgo & Albors, 2008).

Innovation is accepted as a "flow" that starts with a mass of new ideas regarding a specific problem, which are selected and refined until the best are brought to solve it, and eventually to commercialization. Information systems can support the management of the innovation flow. These perspective of beginning and end, and a sequence of steps, not necessarily linear[2], is called 'innovation as a process'. The process of innovation deals with the matter of how innovation endeavors are suitably arranged and ought to be. These models utilize innovation patterns, stages [beginning, progression, marketing, spread, acceptance, or execution] and evaluation points, to construct a process for a new product development (NPD) (Damanpour & Aravind, 2012). The innovation process involves many variables and a considerable risk, and for this reason it can be considered of a complex, uncertain and disorderly nature (Longanezi et al., 2008).

Although some studies related to innovation management are known, according to Melendez, Dávila, & Melgar (2019), there is still little research on this topic. Management innovation corresponds to only 3% of articles on innovation, according to a systematic literature review by Crossan and Apaydin's (2010). Gimenez-Medina (2022), based in a systematic mapping study of capability and maturity innovation assessment models, also concludes that innovation management systems (IMS) are scarcely considered for publication. These results are similar to Birkinshaw & Mol (2006, in Hamel, 2006, p. 82), who cited a query in the Business Source Premier database that resulted in 12,774 scholarly articles on the topic of "technological innovation", and only 114 were specifically dedicated to management innovation. Except for a few cases, the majority of these 114 articles fail to equip businesses with the tools to improve their ability to pursue management innovation.

Considering the diversity of academic literature and IMS, the purpose of this study is to review the most mentioned systems, drivers and tools, and based on their strengths and contributions, present the general lines of a more comprehensive, integrated and pragmatic system for the proper management of innovation, to be usable in organizations of different sizes and kinds of business.

2. Literature review and theoretical framing

The theoretical body which support this research is the open innovation approach (Chesbrough, 2003) - oriented to collaboration with external partners to absorb knowledge and develop technologies beyond the limits of a given company, the systems theory (Von Bertalanffy, 1972) – as a set of elements standing in interrelation among themselves and with the environment, and the total innovation management paradigm (Xu, 2007) – that emphasizes the synergistic linkage among all inherent elements, all employees are innovators and innovation is realized in the totality of time/space of an enterprise and beyond.

2.1 Innovation Management Systems (IMS)

Between the end of the 1980s and the beginning of 1990s, two distinct perspectives of product development process were developed and became the mostly disseminated innovation management approaches: The "Funnel of Innovation" and the "Stage Gates" approaches (Vilha, 2010). Although they were created with a focus on the development of new products, both have also been used for services development (Kitsuta & Quadros, 2019). The Funnel of Innovation was first conceptualized by Clark & Wheelwright (1993, in Teece, 1986, p. 62). Often used in the consumer goods industry, where the number of new product ideas is typically very high, and innovation teams try to use stages and estimates to reduce the number of ideas and prioritize efforts on those most likely to succeed. The funnel provides a general framework for generating and evaluating alternatives, the order of critical decisions, and the nature of decision making (Vilha, 2010).

The Stage Gates or Phased Review Process was developed by Cooper (1994) and is the third generation of a model developed in the early 1960s, called NASA's PPP (phased project planning), which served for the management of contractors and suppliers of the North American space program. Cooper (1994) developed the stage gate system around the five F: (i) Fluidity; (ii) Fuzzy gates; (iii) Focused; (iv) Flexible; and (v) Failure or Fallibility. Stage gates split the development of a new product into phases, each composed of specified, transversal, and parallel activities. The bridge (gate) between each stage controls the process

[2] The understanding that the innovation process is not linear means that it is perceived with considerable overlap, retrogression, false starts and recycling among its stages (Tidd et al., 2005).

and acts as a quality control and checkpoint. The innovation process is subdivided into four stages and five gates, or moments of decision (Cooper, 1994). Starting from the crowd of ideas, the first gate corresponds to the selection of the best ideas for the first stage, of preliminary investigation. Then we move on to the business case assembly, development, and testing and validation stages. Once the last stage is completed, there is the last gate that leads to the product launch. In this model, the organization evaluates its innovation project as it progresses and gradually increases its commitment to the project, and the uncertainties are discussed in each stage (Cooper, 2008). One of the central characteristics of the stage-gate system is that it is multifunctional, thus overcoming a limitation of the original Phased Review Process model, which was predominantly an engineering methodology. Each stage of the innovation process involves activities from many different corporation departments. "There is no 'marketing stage' or 'manufacturing stage', which contributes to reducing the influence created by functional fiefdoms" (Cooper, 2008, p. 5).

Another IMS was later developed by Tidd et al. (2005), which is simpler, generic, and directed to the key aspects of innovation management. The model is divided into four phases: research; selection of technological and market opportunities; implementation (acquisition of knowledge and technology, project execution, launch of innovation and sustainability); and learning and renewal. The innovation process always has the same basic sequence of activities, and the management of innovation requires learning to find the most appropriate solution to the circumstances. This author considers three sets of contextual factors: the strategic context for innovation, the organization's capacity for innovation, and the connection between the organization and the key elements in its external environment. According to the author, innovation management is the construction and implementation of routines in the organization, as a structured and flexible model to deal with a constantly changing environment, to create dynamic capacity. Coutinho (2006) split the innovation process into four stages: identification, selection and prioritization, development and implementation of opportunities, and process evaluation system or metrics. Ideas are the raw material for innovation and idea management (generation, collection, development, evaluation and selection) is the core of innovation management. The authors propose an innovation management system based on the PDCA method (Plan-Do-Check-Action). The act of Planning includes the following activities: bank of ideas, portfolio management, strategic alignment, search for promotion, and organization and people. The act of Developing involves: knowledge management, organizational structure, management of external sources and the "stage gates" process. The act of checking the results implies measuring and comparing them with a pre-established goal, and the innovation BSC can be used. In the act of acting/evaluating, the company must correct unachieved goals and evaluate if expected result are still needed. In addition, it is essential for the organization, creation and maintenance of an environmental intelligence system that monitors the external environment in real time, and a technology prospecting and evaluation system, mapping possible futures in order to know how long that advantage will take. must be lost. Still according to the authors, all these activities of the management system must be coordinated and integrated.

In addition to the four stages recommended by Coutinho (2006), Longanezi (2008) proposed two more: environmental intelligence, and definition of technological and market strategies. According to the authors, these activities, which were respectively included in the stages of identifying opportunities, and of selection and prioritization, are justified by their importance in collecting additional data and supporting better the decision process. Environmental intelligence permeates all levels and activities of the organization, is a complex and time-consuming activity, and deserves a dedicated coordination. The definition of strategy is the activity that should guide the entire innovation system. In the actual generation of innovation systems, the contact with customers or users, starts in the first beginning of the innovation process, there is a greater regularity in the evaluation of projects (Longanezi et al., 2008), and there is parallelism and high level of functional integration.

Later, Vilha (2010) introduces the new concept of Technological Innovation Management, which considers three dimensions: strategic, tactical, and operational dimensions. The adoption of innovation strategies aims to generate knowledge capable of producing products and services that generate sustainable competitive advantages. Both the competitive strategy and the innovation strategy must be interdependent. The tactical dimension aims to develop an innovative organizational climate and structures for innovation, such as: organizational learning; leadership strategy; skills mapping; and knowledge management. The operational dimension aims to establish the routines for generating, implementing, and evaluating innovation. In this concept innovation is not something intuitive or random in the organization.

The strategic management of innovation is a modern and fundamental concept which must be present in innovation management systems. The need for a more strategic perception can help organizations to choose the best partnerships, the needs of consumers to be met and the best time and way to bring the product to the market. It became more evident because innovative organizations not always make a profit and grow in business, and sometimes a fast second participant or even a slower third entrant perform better than the original innovative organization. Those coming in second learn from the mistakes made by the forerunners, but there are also other factors. Innovation management must consider three fundamental factors, according to Teece (1986): the structure of the organization's complementary assets and when they are specialized; the organization's positioning in the market with respect to critical complementary assets; and managing market entry. Complementary assets and differentiated routines and skills provide the company with dynamic capabilities to sustain its competitive advantage, which must be systematically rebuilt (Espinosa-Cristia, 2019).

Xu (2007) brings a novel and a broader paradigm of innovation management - Total Innovation Management (TIM), based on three distinct areas of research: the innovation theory of the firm, the resource-based view (RBV) of firm, and the complexity theory. The definition of TIM is the management and reinvention of an innovative value network that dynamically combines conceptualization, strategy, technology (including IT base), structure and business process, cultu-

re, and people at all levels of an organization. The totality is expressed under three aspects, for Tidd et al (2005, p. 15): "all technological and non-technological elements (strategy, culture, organization, institution, and market).; (…) all individuals involved; (…) and innovation at all time and in all spaces". From an ecosystem perspective, TIM emphasizes the synergistic linkage among all inherent elements and that all employees are innovators and that innovation is realized in the totality of time/space of an enterprise. TIM may be defined as an ecological system directed by strategy innovation whose function is to accumulate and enhance core competency to win sustainable competitive advantage. The TIM offers a more dynamic, more unified and integrative theoretical framework, and better view of the core issues of the innovation management field.

The degree of novelty of an innovation is pursued influences the management of innovation and the IMS. Radical projects may require more specialized arrangements, a broad revision of routines and temporary solutions. Disruptive innovation is even more problematic because is an experimental process and can imply a significantly different "value network" (Bessant & Phillips, 2013). In discontinuous conditions, new competitors win more often than established operators (Bessant & Phillips, 2013). According to Lilja et al. (2017), previous research has found that organizations which survive long-term need to be adaptive and innovative. Such ability is commonly described as Organizational Ambidexterity (Tushman & O'Reilly, 1996, in Lilja et al., 2017, p. 24), which refers to the ability to simultaneously pursue both incremental and radical innovation. Consequently, the IMS should be flexible, to be adapted to context, characteristics, and the type of innovation sought – incremental, radical, or disruptive (Sánchez Ocampo et al, 2019).

After a systematic review of literature to map the state of the art in published firm-level research about innovation management systems, Cortimiglia et al. (2015), identified sixteen innovation process models papers and nineteen papers about innovation drivers, which are aspects, elements, and firm characteristics that support innovation processes. Based on this research, the authors concluded that existing IMS are excessively generic and rarely use innovation drivers and managerial tools to improve the innovation management. The empirical research is dispersed across different fields of activity, business, and company size, and lacks generalizable evidence. Other literature review, about innovation management models, by Bagno, Salerno & Silva (2017), reached similar results. Based on sixteen different models, as common characteristics, the authors found they focus mainly on processes, whether processes like stage-gates or macro processes, are oriented to medium-large established companies, their methodology is similar, and focus is on incremental innovation.

There is no evidence of a 'single' or 'best' innovation management model or system. The available systems are mostly focused on R&D management and its stages, and rarely employ the management tools, techniques and knowledge available, giving an excessively theoretical perspective. Although there is no universal innovation management formula, some functions and techniques should be present for innovation to take place. The innovation management literature converges to a generic, "sequential four-step innovation process: idea generation; idea evaluation, selection, and prioritization; innovation development; and innovation implementation or launch" (Cortimiglia et al., 2015, p. 1703).

2.2 Innovation Management Systems Effectiveness

Academic evidences have shown that innovation management and innovation management systems can enhance companies' innovativeness, and they are essential for the companies' growth and sustainability. These references from the academic literature and empirical studies support the effectiveness of the systems, axes, activities and concepts.

A research on innovation management and their impact on organizational performance of the service industry in Pakistan, was published by Qureshi et al. (2008). Questionnaires were received from 145 executives responsible for innovative actives in IT and Banking sector. The main findings of this research comprises that the most influential impact on organizational performance and market performance is made by the variables named as innovation management practices and radical innovation.

López-Mielgo, Montes-Peón, & Vázquez-Ordás, (2009), reviewed the literature about the effects of quality management in innovation, considering the implementation of hard components (HC), which are the control of processes and products to comply with quality standards and satisfy manufacturing specifications, and soft components (SC), which are the measures to obtain involvement of managers and employees in the quality management: training, learning, and internal cooperation or teamwork. The authors found that HC inhibits innovation, especially radical innovation, as the rationality and control of the tasks imposed in the production process drown the creativity necessary to impose significant changes in the way things are done. Conversely, firms that implement SC tend to be more innovative.

Cerezo-Narváez et al (2019) studied the robustness of the implementation of an IMS, of a Spanish innovative small company, an industrial metrology and quality services provider, in the Aerospace Industry. According to the authors, the management system has enabled the company to: gain a deeper comprehension of the organizational context; optimize its innovation endeavors; foster leadership and commitment from top management, as well as organizational goals; structure efficient innovation teams and units; conduct technological surveillance, and get more patented technology; plan the development of R&D projects; among many others. The implementation measures taken by this SME are generalizable to other SMEs.

A study conducted by Simon & Honore Petnji Yaya (2012) has revealed that for the generation of customer satisfaction and innovation, better use of the management systems is the most critical predictor of process, organization and marketing innovation, and the internal cohesion, which could ensure that the organization's objectives are aligned with those of the employees, dealing properly with the climate and communication among employees, was the most important factor in fostering innovation.

A study was conducted by Martínez-Costa et al. (2019), in 200 Spanish manufacturing organizations, with more than 100 employees and at least five years old of functioning, to understand performance implications of a standardized innovation management system. Based on the research findings, the IMS influenced positively all types of innovation. Administrative innovation was found to partially mediate the connection between the IMS and process innovation, a phenomenon not observed in product innovation. The IMS influences directly the innovation processes and indirectly promoted advancements in non-technological innovations. There is some indication that the company's performance is enhanced through an indirect influence on product and marketing innovations.

Zaoui et al (2021), based in a research about innovation practices in 57 Moroccan companies operating with international management standards, highlighted the role of information technology to support certain key tasks of the R&D&I process, such as Technological Surveillance, Technological Forecast, Creativity, and Knowledge Management. The authors also recommend avoiding "infoxication", which means the excess of information that causes the recipient an inability to understand and assimilate it.

3. Materials and Methods

This investigation is an exploratory research. This approach explores research questions that are understudied or for which the data collection process is difficult (Hunter et al., 2018). The exploratory research method employed was a literature review, to summarize existing knowledge and understand the current state of research on innovation management systems.

The main research questions that guided the review were: "what innovation managements systems are available?", "is there a generic model for innovation management systems?", "what techniques, methods and innovation management tools can be incorporated into a management system to strengthen it?", "what evidences exist about innovation management systems adoption?".

The research plan for collecting academic studies was adopted in the scientific databases Web of Science, Scopus, EBSCO and google scholar. Literature extraction was carried out in November 2022, and the keyword used was "innovation management system". The search was applied to the titles, abstracts and key words in all databanks, with the exception of google scholar, in which the query was applied just on the publication title. As inclusion criteria, were accepted only publications in English, Spanish and Portuguese, published since 2010, and as documents types, papers, literature reviews and proceeding papers. In order to expand the bibliographic research, the snowball technique was additionally used, searching in the reviews found, the works and the authors of reference about the main research questions.

The extraction of documents in the four databases using the above mentioned keywords, applying the inclusion criteria mentioned above, brought 63 items from Web of Science, 143 from Scopus, 50 from EBSCO and 95 from google scholar. From the total of 351 documents, there were excluded 178 duplicated items and remained 173 items, which abstracts were analyzed by two researchers regarding its adherence to the main research question.

As exclusion criteria, were not acceptable studies which weren't directly about the research questions (as innovation, innovation management, innovation managers, technological innovation, and others), very similar publications, and incomplete studies. Following this analysis, 76 abstracts were excluded.

Next, the full text for the 97 remaining papers were analyzed by two researchers. The aspects considered in the full content analysis included: research approach (empirical or theoretical), methodological procedures, empirical application, proposition of a model or system, phases/steps/stages of the model or system, drivers of innovation, specific innovation management tools or techniques. At the final of the review stage, 37 researched items were retained, between academic papers, reviews and conference papers. The snowball technique performed included 10 more studies.

Potential biases or gaps in the literature search and selection process must be recognized, and can be attributed for the languages selected, the year limit of 2010 for publication, potential exclusion of relevant sources and selection process.

4. Results and Discussion

4.1 An Innovation Management System Proposal

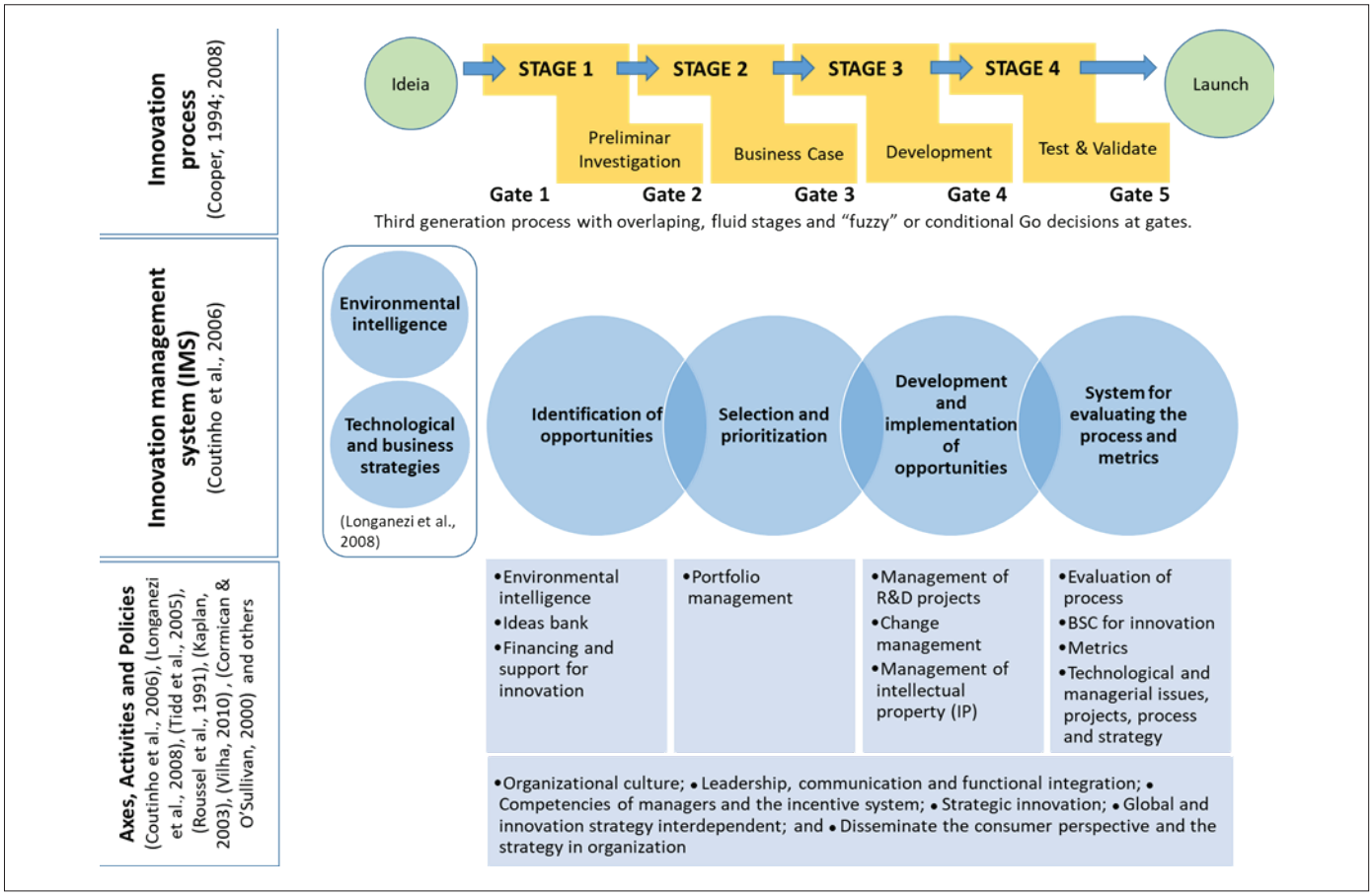
The innovation management system here proposed is a comprehensive platform, composed of subsystems, policies, activities, managerial tools, and routines. Below, we discuss in more detail the three parts of the system, which are based in the perspective of innovation as a process, the stage gates process development (Cooper, 1994, 2008), the paradigm of Total Innovation Management (Xu et al, 2007), and the conceptual structure proposed by Coutinho (2006) and Longanezi (2008). Figure 1 summarizes the proposed system.

In the first part of figure 1, is the innovation process, as described by Cooper (1994, 2008). It provides the main logic and inspiration for the innovation management as a process, with stages and gates, from the ideas as a starting point until the market launch, and the characteristics of fluidity, flexibility and parallelism. The second part is the innovation management system general guidelines, with the stages as proposed by Coutinho (2006) and the two optional stages suggested by Longanezi (2008), that gives the broad framework which will guide the structural managerial axes and activities, that comes next. And at the bottom, is the third part of the figure, with the managerial structure, and is subdivided in two. In the first, are the axes or subsystems, activities and policies, related to each stage of the proposed management system. In the second, are the transversal activities, which permeates all the innovation process and its stages.

This managerial structure, with activities connected to the stages of innovation and transversal activities, gives a more systemic perspective, with complementary, interdependent and integrative acti-

vities. This broader perspective is aligned with the Total Innovation Management perspective (Xu et al, 2007), and aims to cover the innovation process and its interdependencies. The open innovation approach (Chesbrough, 2003) is a general strategic guide, which is essential in some stages and activities, to encourage innovation and collaboration with external partners, such as customers, suppliers, research institutions, startups, etc, and workers. Emphasis might be placed on creating strong networks with intimate ties, such as becoming close to customers to understand their requirements and develop solutions with them, or collaborating with important suppliers to expand the breadth of the company expertise (Bessant & Phillips, 2013).

Figure 1. Proposed model of innovation management system, based on Cooper (1994), Coutinho (2006) and Longanezi (2008).



4.2 Opportunity Identification

The potential of growth of an organization depends on its ability to generate and explore new ideas, markets and technologies, and sometimes to invigorate older ideas in a new context. The opportunity identification stage has three main axes or subsystems: environmental intelligence, ideas bank, and financing and support for innovation.

The environmental intelligence axis may involve a wide range of activities, such as: assessing the external environment and analyzing market and technological trends; analyze the organization's internal environment, technical and organizational skills, technological platforms, relationships and partnerships, and competitive advantages and weaknesses; analyze external sources of knowledge, innovation, technological prospecting and fostering innovation; identify intangible assets to be protected, such as human resources, technical and organizational knowledge, and matters subject to intellectual protection; and manage internal knowledge, so that external and internal intelligence efforts are linked. This axis has great challenges because it is transversal to all innovation process, serving different areas of the organization (technical until senior management), and working with rich and complex data and information, which require critical analysis, and computational tools, databases and organizational routines.

According to Santa Soriano, Torres Valdés, & Magallón Pendón (2017), innovation is not only technological, but also relational and, therefore, relational strategy emerges as an important part of the strategic and competitive intelligence of organizations. A new model of public relations with external and internal actors is required.

The second axis is the core of the opportunity identification stage (Longanezi et al., 2008) and is dedicated to the activities of generation, collection and organization of ideas, in order to identify the potential value of each idea, with the greatest basis for the selection stage. Encouraging quantitative generation is essential, mainly with

methods that provoke ideas with high potential for the business (like CPS, Lean Start-up, Agile methodologies and DSRM). The quality of the ideas often determines the success of the innovation process and this depends on the level of creativity applied. Creativity is the raw material for innovation and is a function of: expertise, creative thinking skills and tools, and motivation (Amabile, 1998). The organization must seek an environment conducive to the development of these factors. Although managers believe in its importance and invest in the generation of ideas, creativity is more often contained than encouraged.

In terms of sources of ideas, it is important to emphasize that the previous generation of R&D identifies just the visible and explicit needs (Coutinho et al., 2006). But most needs are latent or invisible and are unlikely to be met. The innovation built only on explicit knowledge is, in general, continuous and incremental. In the traditional innovation system, the responsibility for acquiring knowledge is divided between the marketing area, which assesses the needs of customers, and that of R&D, which provides the technology (Roussel et al, 1991). The alternative is the basis of fourth generation R&D and comprises the participation of suppliers, salespeople, customers, and others, in joint experiments and the subsequent division of the knowledge obtained, and the dissemination of information in the organization, extinguishing the old monopolies. This approach facilitates radical innovations.

The systematization of the idea generation process can be carried out through an idea bank, open to employees and in some cases to strategic partners. The ideas raised should be sent to technical and market specialists for valuation. In this valuation, the risks involved in the development of the idea must be identified and quantified. The bank of ideas must be centralized and bring together the opportunities identified by all sectors of the organization and accept suggestions from external partners (Coutinho et al., 2006). Centralization facilitates portfolio management.

The third axis corresponds to the search for financing and support for innovation. It should be a daily activity. Innovating involves risks and the way to minimize is to share them with partners, based on tax incentives, direct subsidies to R&D, venture capital actions and others. A management subsystem must be implemented for external sources of innovation, which makes it possible to: know the available sources; identify those with potential; manage contracts; measure results; monitor the internalization of knowledge; and guarantee its absorption in the company (Coutinho et al., 2006).

Gathering information and obtaining resources are important for the company's positioning, but insufficient to guarantee good results. The construction of unique conditions for the company depends on rigorous knowledge management. It consists in a systematic approach to increasing the value and accessibility of the organization's knowledge, to achieve maximum business effectiveness and to propagate innovation, with actions to manage the creation, capture, synthesis, dissemination to the different and sometimes specific levels and departments, and application of the organization's collective intelligence (Vilha, 2010). The knowledge distributed will sum with the experiences and knowledge already available, generating new, in a spiral of knowledge (Longanezi et al., 2008).

'Triggers' are necessary at this stage of the innovation process (Tidd et al, 2005). One of these triggers aims to differentiate mistakes from failures that can open completely new directions for innovation, or a distraction from a potentially useful result. Finally, it is essential to have communication and connection routines between the different organizational areas, so that the user's perspective is disseminated into the organization and not simply retained as marketing information, and the vision and strategic planning can reach the entire organization.

4.3 Opportunity Selection and Prioritization

The identification of opportunities raises a wide range of possible targets, answering the question: 'what could the organization do?' This stage aims to select and prioritize the best ideas, regardless of their level of technological maturity. According to Bessant, J., (1991 in Tidd et al., 2005, p. 364), research had shown that organizations that innovate only on impulse are underperforming, sometimes adopt expensive and complex innovations that fail with competitive advantage. The successful selection requires: adequate information for the decision-making process; monitoring selected projects; a method of selecting and prioritizing projects consistent and coherent with the elements mentioned; and a clear and well communicated organizational and innovation strategy. Tidd et al. (2005) also highlighted the importance of understanding the main parameters of the competitive game (markets, competitors, external forces, etc.) and the role of technological knowledge.

Choosing and prioritizing ideas of real value requires that enough quantity and quality information is available (Longanezi et al., 2008). Another issue is that regardless of the resources available, this step often involves making difficult choices. Any method of choosing projects need to be viewed in a strategic and flexible way, and must be rigid enough, as uncertainties and assumptions are being replaced by real knowledge (Tidd et al, 2005). In a complex and uncertain world, it is almost impossible to make detailed plans before the game and follow them systematically.

This stage focuses on the portfolio management. It comprises the selection and prioritization of the opportunities identified and must involve strategic components. It is essential that the organization avoids the risk of having the know-how, but not having the know-why in its innovation process. Moreover, the definition of a balanced project portfolio is more important than the best choice of isolated projects (Longanezi et al., 2008). Portfolio management and project prioritization comprise strategic choices (Roussel et al, 1991), and the definition and dissemination of a clear and easy to understand organizational strategy throughout the company help the strategic alignment.

A method for portfolio management is needed and the most used, according to Coutinho et al. (2006), are: maximizing financial return; competitive impact of technology; market segments served; non-fi-

nancial return; long-term return; balancing the project portfolio; and strategic alignment. The organization have to choose the method of selecting and prioritizing innovation projects that is appropriate to its needs and competencies, and the intended strategy. Product portfolio management and prioritization of innovation projects defines the application of scarce and vital resources (Roussel et al, 1991). Mistakes can lead to losses in efficiency and competitiveness.

The business or market strategy must serve as a guide for the organization during all innovation process and its decision triggers, but is specifically important in this stage because that's when projects and portfolio are mostly decided, especially in terms of incremental innovation. The selection of best innovation opportunities, projects and portfolio require long term view, planning and objectives, which are helpful to order resources for a meaningful, viable and constructive posture (Longanezi et al., 2008). The strategic planning must be seriously and carefully built, and linked with other activities done in parallel by the company, as the environment intelligence. The open innovation approach (Chesbrough, 2003) enrich this planning process, encouraging collaboration with external and internal partners.

The theme of technological strategy emerged in the 1980s and it has grown as the use of technology has expanded as a competitive tool. The technological strategy considers aspects such as market prioritization, consumer needs to be met, alliance networks and business ecosystem, product strategies to follow, opportunities along the supply chain, existing standards of technologies, mergers and acquisitions of interest, regulatory tendencies and others. Technological strategy, according to Longanezi et al. (2008), is influenced by: available resources; competitors' strategy and industry evolution; technological development; the internal cultural and structural contexts; and the company's strategic management capacity. Technological strategy must be coherent with the firm's global strategy.

4.4 Development, Implementation and Protection of Opportunities

The stage of development, implementation and protection of opportunities has three main axes or subsystems: the management of R&D projects; change management; and the management of intellectual property (IP).

Most of the activities in this stage, and the most important, correspond to the management of R&D projects. Often, R&D projects are riskier, meaning a more cautiousness approach is required. The beginning is based on the product brief, whose information is often presented in technical language, giving rise to the preliminary specification of the prototypes. Once produced, the prototypes are analyzed and their results evaluated jointly between R&D and the commercial and marketing areas, otherwise the development cycle is restarted (Longanezi et al., 2008). The winning prototypes must be submitted to research with the end user to validate the concept and reduce commercial risk due to issues eventually not observed by the development team. Once the prototype was validated, the process proceeds to the implementation stage on an industrial scale, requiring careful monitoring at first to verify the reproduction of the conditions obtained on a pilot scale. Finally, the product enters the market and the commercial, market or post-market area, depending on the business segment, starts to coordinate the process, being responsible for presenting the new product, recommending its use and applications, prospecting for new markets. and post-market monitoring. In terms of the Technological Maturity Level (TRL) scale, most of the technological development and maturation process, and their costs, occur at this stage (Longanezi et al., 2008). R&D activities do not exist as isolated and independent operations and, must be aligned with the corporate strategy (Bremser & Barsky, 2004), which was built in the previous step.

In parallel to the technological aspects of the innovation development, there is the process of identifying, exploring and preparing the market for the launch of a new product or service. Even if the product or service is technically excellent, there is no guarantee that people will adopt it or continue its long-term use. Several activities are included in the launch of the product on the market, such as: customer test; marketing test; develop a marketing strategy; develop a marketing plan; organize support; launch on the domestic market; and change management (Tidd et al., 2005).

Effective management of R&D projects means achieving a good match between the demands of a development project and the required operational structure. In a 10-year study of 2,899 projects by Souder, W. & Sherman, J. (1994 in Tidd, et al., 2005, p. 388), 46% of the projects were successful, but the project management structure was the main determinant. Coutinho (2006) also highlight activities related to the organization and people in the R&D stage. The company needs to map its structural, organizational and personal competences for the development of each project. In defining the portfolio, the question of existing competences and to be acquired must have been considered, but this question must be reevaluated, because changes can happen. Absences and weaknesses can be overcome with partnerships, that were identified by the environmental intelligence axis.

At this stage of the innovation process, attention should be paid to simplifying the product and design, without the risk of erroneously reducing time to market, taking advantage of the availability of tools such as simulation, rapid prototyping and others. What is defended is the practice of the so-called 'learning-before-doing', a powerful source of innovation, as opposed to 'learning by doing'. Estimates suggest that up to 70% of the cost of producing a commodity is determined in the design phase, however, most companies spend less than 5% of their budget on product development in design, and start the manufacturing stage as quickly as possible (Tidd et al, 2005).

Managing innovation projects is more than adapting resources according to time and budget. Dealing with unexpected and unpredictable events and implementing successful projects requires flexibility, creativity and the integration of knowledge, through interdisciplinary teams, through simultaneous work, and the use of simulation and other exploration technologies, to anticipate downstream problems and reduce costs and time, while improving the quality of innovation (Tidd et al, 2005).

For the R&D project management stage, each R&D project should be designed according to its peculiar characteristics, such as its strategic importance and the opportunity context. Sometimes, depending on these characteristics, the implementation and management of the project must be done partially or even completely apart from the innovation management system, to configure maximum flexibility and speed. This configuration follows the logic of "projectification". In an integrative literature review on the scope of "projectification" research from 1995 until 2021, projectification, as a managerial approach, is seen as an organizational initiative to expand the presence of projects in organizations or a move from mass production to ad-hoc workflows and using temporary projects (Jacobsson & Jałocha, 2021). This concept is not necessarily contradictory to the management system, but complementary, when its application is opportune (Jacobsson & Jałocha, 2021).

The second axis of this stage is change-management. Since many innovation processes often bring about important changes in the organization, the issue of managing change and overcoming resistance to innovation needs to be addressed. Planning for such organizational development, and creating a structure and having people dedicated for management of change, is important in the innovation implementation strategy and in the launch of the product or service. Implementation difficulties can be reduced by involving those who are likely to be affected by the change in the formulation of the strategy (Tidd et al, 2005).

The third axis is that of intellectual property management, which should help to build an intellectual protection strategy. Its main objective is to defend the knowledge generated and intellectual property in the organization. The activities of this axis are present at all stages of the innovation process, from the development of the idea. In the activity of implementing innovation projects, the protection of intellectual property is crucial because it will guarantee the exclusive right of production and commercialization and the greatest financial return.

Intellectual property management can take care of a wide range of activities, such as: scientific, technological, economic and market research; prospecting to identify partnerships; legal prospection to support issues related to intellectual property rights; patent feasibility assessment; registration, granting and maintenance of intellectual property rights with national and international authorities; protection of intellectual property; portfolio management of IP contracts; management of technology transfer contracts; dissemination of the intellectual property culture; and the establishment of technological intelligence practices, which consists of the routine of collecting technological information in patent instruments.

In addition to these axes, it is important to highlight that the process of bringing ideas to successful innovation requires gathering different knowledge, people and organizational departments, through previously established steps and routines, working together and sometimes simultaneously. But the tendency is to execute it as a just simple sequential process, changing to different functional groups as the project progresses (Tidd et al, 2005). Companies also need a R&D with good capacity, inserted in their strategy (Coutinho et al., 2006), and integrated with the whole organization. Failure to observe these precepts leads R&D to respond to crises and constant changes in priorities.

4.5 System for Evaluating the Process and Metrics

The final stage of any innovation process must be a planned and structured review, employing indicators that are sensitive to what is evaluated and an attempt to collect, organize and disseminate the learning, which will feed the next innovation process. This is an optional stage and many organizations do not carry out any revision (Tidd et al, 2005). Other organizations conduct some kind of structured review or post-project audit, but this does not guarantee learning, as the emphasis can be on avoiding blame and covering up mistakes.

Effective learning requires a commitment to open, critical, honest and informed review (e.g., regular lessons learnt meeting). The development of such learning skills is fundamental to learn from activities, successes and mistakes, to strengthen the innovation management capacity. A critical aspect and an important difficulty in this process is to receive valuable information from the business units (Donnelly, 2000). Although the difficulties and complexity, the costs of not managing learning are often high (Tidd et al, 2005).

The oldest and most used indicators to measure the innovation effort are those based on R&D statistics, such as spending or labor allocated to R&D (Coutinho et al., 2006). The metrics most often used to measure R&D performance, for Donnelly (2000), are: R&D spending as a percentage of sales; new products approved/launched; number of approved projects in progress; total active projects supported; total patents deposited/pending/granted; current percentage of new product sales; percentage of budget resources dedicated to R&D; change in the R&D staff; percentage of resources dedicated to the maintenance of existing products; and average development cost per product. The Oslo Manual proposes indicators related to the performance of the process, such as the value of sales with products developed in the last three years (OECD, 1997).

Twenty-eight experts on innovation and measurement, brought together for an advisory panel by Adams et al (2006), to discuss about metrics used for management practice, came into a consensus, recognizing the existence of many measures on innovation, but noted the absence of measures well aligned and that express more directly the activities and stages of the innovation process. Coutinho (2006) also pointed out that recent studies call attention to this absence. Based on a broad review of the literature on metrics to measure R&D performance, according to Bremser and Barsky (2004), an organization needs a performance measurement system to support evaluation decisions at each stage gate, that should be integrated, understand innovation as a process, and whose indicators are linked to the organization's strategy. Although some studies related to the measurement of innovation are known, some authors agree that there is almost no research on the measurement of innovation management (Melendez, Dávila, & Melgar, 2019).

For Longanezi et al. (2008), the evaluation system should focus on the final product and in the innovation process. The Balanced Scored Card - BSC of innovation, developed by Kaplan (2003), emerged in this movement to search for a metric for the management of innovation at the organization level. According this model, innovation management encompasses four main processes within the organization: identifying opportunities, managing the R&D portfolio, developing new products and launching them. The act of checking and controlling the results for each process implies measuring and comparing them with pre-established goals, as time, cost and results obtained. It also links strategy to operations.

The metrics for the evaluation of the innovation process should be considered from four perspectives (Longanezi et al., 2008): generation of ideas; operationalization of the product development process; external vision (evaluation by consumers, chain supply and other stakeholders); and strategic and financial alignment. These perspectives allow internal processes to be tracked, aspects with potential impact on the final project to be identified, and intermediate results to be measured. For the first perspective, the authors highlight the importance to evaluate the impact of the methods to stimulate new ideas. For the second, they highlight the compliance with deadlines and budgets, the speed of analysis, and the degree of success in the implementation of processes. For third, they suggest an assessment of customers and partners on the results of the IMS, and an assessment of the degree of novelty of products and services and of new markets. Regarding the last perspective, the authors suggest the evaluation of the strategic alignment of the product portfolio and projects resulting from the IMS and the monitoring of goals around the economic results.

Two dimensions of issues and two sets of elements need to be considered in depth in the stage of evaluation and review of the innovation process (Tidd et al, 2005). In connection with the first, technological and managerial issues should be evaluated. In relation to the set of elements, the selected and supported innovation projects and the innovation process, subdivided into its different stages, should be evaluated. A third theme that can be evaluated is the evaluation strategy itself. The authors understand that there are several mechanisms for the evaluation stage, such as post-project reviews, auditing and benchmarking. For the innovation projects which were supported, a simple learning cycle model, with post-project reviews, seems to be adequate. On a larger scale, to assess the innovation process, the performance at each stage and the innovation management system itself, external audits have been increasingly requested by external agencies and customers.

The evaluation and monitoring of the innovation process require instilling discipline, organization and formalization, without extinguishing the necessary flexibility and creativity. Most companies find difficult to adopt basic metrics linking R&D initiatives with the organization's results. The use of a management system such as the stage gate, allows to overcome the difficulties for the evaluation of innovation, analyzing the product development cycles in its various phases, employing metrics for each major critical stage, and allowing the correction of directions earlier and at different opportunities. The innovation projects, to move to the next technological level, they often need to go through a review process. Each gate is managed by senior management and offers the opportunity to decide whether to continue investing (e.g., "to go" decision). A product that look good at the definition stage can be blocked afterwards, reducing wasted time and money.

4.6 Transversal Activities

The four proposed stage gates (Coutinho, 2006) must have its axes and activities implemented in a nonlinear, fluid, fuzzy and flexible mode, as Cooper (1994) conceived. Additionally, there are transversal activities which do not pertain to any specific stage, they permeate all the innovation process and are very important for the success of each stage and the innovation process. The innovation potential of a company is not due to a single skill but to the whole set, and their internal and external interrelations, building an "innovative capacity" (Coutinho, 2006). Most available models focus only on the stages.

For our model, we propose some transversal activities, but depending on the organizational characteristics, context and opportunities, more activities can be added. The activities proposed are: an organizational culture for innovation, motivated and competent professionals (which include specific focus on management team), an inspiring and visionary leadership, an incentive system for innovation, a risk management process, business and innovation strategy interdependency, and the consumer perspective and the company strategy disseminated in organization.

It is essential for an organization to have a culture[3] for innovation, which can induce the intensity of the innovative process (Vilha, 2010). Companies have innovative capabilities, which are comprehensive characteristics that facilitate and support innovation strategies, and that must be effectively managed (Cormican & O'Sullivan, 2000). The innovative capacity of a company is based on the development of an innovative organizational culture and competences (knowledge), which must be mapped and strengthened.

The innovation management process seems to be less dependent on a formalized organizational structure and more dependent (or stimulated) by managerial practices aimed at innovation and the massive participation of the largest possible number of employees (Salerno et al., 2010). The culture of innovation consists of motivating and coordinating people to develop and implement new ideas to achieve the results planned by the company, within a context of change (Vilha, 2010). The need of focusing on the non-technical components of innovation systems have been emphasized in the research of Damodharan et al. (2022), in which they conclude that internal company culture is very important in nurturing corporate employees' passion and involvement, and it encourages experimental business ideas and potential commercial value by fostering innovation and ideation.

[3]Organizational culture is a system of meanings shared by the members of an organization. It aims to transmit behaviors and norms through interaction between members (Vilha, 2010).

As a system incentive for innovation, Mavroeidis & Tarnawska (2017) highlights the managerial recognition of creative ideas, as a crucial component of the organizational climate, support, and reward structure. The authors also stress that not rewarding risk taking and lack of toleration of failure are key barriers to innovation.

Among the critical success factors, Sánchez Ocampo, Iacono, & Leandro (2019) highlight leadership, culture, communication, risk management and functional integration, to favor high-performance innovation management. Tidd et al. (2005) highlight the importance of managers' skills, experience and the ways in which their performance is judged and rewarded (or punished), to influence the innovative behavior of companies.

Risk management is a strategic process to be adopted in the management of innovation (Cerezo-Narváez et al, 2019), and involves some difficulty, as risk is an individual perception, in a scenario whose probability is known. According to Silva & Dutra (2021), based on a literature review, the introduction of the ISO 31000:2009 standard for risk management made this process more standardized, consisting of seven steps: establishing the context, identifying the risk, risk analysis, risk assessment, risk handling, communication and consultation, and monitoring and review. The definition of risk in Standard ISO 31000: 2009 is simple and straightforward: effect of uncertainty on objectives, and risk management corresponds to coordinated activities to direct and control an organization with regard to risks. Risk management needs to be incorporated into the organization's practices and processes, and into the innovation management system, and its activities. There should be an organization-wide risk management plan, integrated with other organizational plans, such as the strategic plan.

As the last activities, innovation management needs to be implemented in a strategic way (Teece, 1986), with clear, understandable and communicated strategy and objectives, to the entire organization, and aligned with the company's overall strategy (Vilha, 2010). The strategy must serve to guide key decisions, such as: the choice of the consumer need to be met, the product to be elaborated, the assets to be mobilized to make the product viable, the best partnerships, and questions regarding the launch of the product on the market.

5. Conclusion

There is an increasing interest in the expansion of innovation capacity at national, regional and local innovation systems, for business ecosystems, expanding research and development public and private financial support, and reforming the S&T legal framework. However, the success of governmental policies is ultimately determined by the frontline organizations who are the actual providers of goods and services to society (Howlett et al., 2015). The micro-level dimension, innovation management and innovation at organizational scene, contrary what is expected, have not been received much attention. Innovation management systems are still a new process, but evidences show they can provide good results and contributions.

The adoption of an innovation management system (IMS) is a high-level organizational decision and must be aligned with its strategic objectives. The IMS is a great platform, with subsystems, policies, activities and tools. This platform enables the collection of ideas, to organize, select and identify their potential value to transform them into opportunities. In addition, according to Faria (2018), there is much more in the IMS, as: implementing a new organizational culture; promoting technological cooperation links; encouraging internal sharing; developing strategic partnerships; facilitating access to more advanced knowledge; supporting an excellent technical staff; increasing access to public and private resources for R&D; interacting with actors in the innovation ecosystem; and providing incentives for projects with greater impact and potential for technological disruption.

This study presents the general lines of an innovation management system for institutions of different characteristics and kinds of innovation pursued, which must be adapted according to specificities and possibilities. The system is originally based on the stage gates or Phased Review Model Process, developed by Cooper (1994), and in the philosophy of the five Fs, with more pragmatism, bringing it to a more current context of open innovation, collaborative networks, and innovation ecosystems. The management system follows the system proposed by Coutinho (2006) and Longanezi (2008), who performs a more synthetic application of Cooper's model (Cooper, 1994), segmenting the innovation process in four stages, and includes a transversal axe of strategic and structural activities, strengthening and giving more management resources, such as: the importance of environmental intelligence and knowledge management (Longanezi et al., 2008); communication routines, intra-organizational connection and user/consumer perspective (Tidd et al, 2005); the management of change (Tidd et al, 2005); the development of a strategy and structure for the management of intellectual protection; the emphasis in the creation of a more innovative environment and a new organizational culture (Faria, 2018); the leadership role, the manager's competencies and the incentive system; and the risk management process (Cerezo-Narváez et al, 2019).

The proposed model reflects the current generation of innovation research, based on the theory of open systems and innovation ecosystems, the Total Innovation Management (TIM) perspective (Xu et al, 2007), and the most recent generations of research on innovation management models, which are dedicated to integrated models, systems integrations and networking. This perspective advances in relation to the concept of R&D as a system.

This proposed IMS can be useful to companies without a structured R&D or a systematic innovation management, but that wish to do so, or to companies that conduct their innovation process, either inside or outside their limits, but who want to evaluate how to improve it and want to apply this model to improve their innovation process. The system is a guiding structure for all kinds of enterprises that desire to enhance their innovation capacities, with a sort of inventory, based on a systems approach, of what the company should implement considering its overall innovation aspirations and capacities.

Phased innovation management systems have limitations. They focus on monitoring and controlling the technical risk of projects, and are effective and appropriate for this. However, managing technical risk can sometimes not be the main objective and speed can be more important for results. The balance between technical and market risks can require adaptation to the project management system, empowerment of managers and a lesser emphasis on formal control. The degree of complexity of a project determines the development cycle lengh. It's important to avoid the one-size-fits-all mentality, which creates a system tailored to the largest and most complex projects. The innovation management systems in phases, due to their formalism and stages (Smith & Reinertsen, 1992), also fight against partial information, hampering them to move on to the next phase only when the information package is complete. At last, the central innovation process, from opportunity identification until market, is inherently linear and too product-centric (Tidd, 2021), and these limitations must be monitored and weakened as possible.

Innovation management ought to additionally take gain of possibilities springing up from partnerships and adjustments within the ecosystems wherein businesses are inserted. Not all innovation strategies are always performed via way of means of the identical organization, and now no longer all innovation control machine desires to be performed via way of means of the identical organization. The most important is that the links along the innovation process communicate with each other.

Although the increasing initiatives and funds to accelerate the innovation capacity of organizational environments, business ecosystems, and innovation systems, there is still limited knowledge about the management of innovation, and the use of a system and routines for this purpose, about what works best and under what conditions. It is still a new and expanding process, which needs more systematic and mainly empirical scientific research. This research is expected to contribute for future theoretical studies on R&D and innovation management theory and models, for empirical studies about the effective use of management systems in innovation, and can be useful to practitioners and managers.

The implementation of an innovation management system is neither a quick nor an easy process and faces many difficulties, such as resistance in the internal culture of the organization, with the false perception that there would be an inhibition of creativity and an excess of control, the challenges of knowledge management, including tacit, undocumented and explicit knowledge, and the difficulty of strategic alignment between the production of ideas, the creation of a portfolio and the launch of new products, so that there is no room for solutions really original. Most management innovations took several years to implement, and in some cases it was impossible to say with any precision when the innovation actually took place (Birkinshaw & Mol, 2006).

The challenges and difficulties for innovation and innovation management are many and diverse. But the growing interest and the need to accelerate the innovation capacity of organizational environments, business ecosystems, and innovation systems and subsystems, demands that these challenges should be faced. To improve the performance of ICT, Universities, Research Centers, technology parks, large and medium-sized organizations, start-up, technology-based companies, and other actors in the innovation ecosystem, the improvement of innovation management and the implementation of a system of innovation management or some of its subsystems, are possible and necessary paths.

Acknowledgment. This research was done in partnership between the Oswaldo Cruz Foundation (Fiocruz), from the Ministry of Health of Brazil, and the Unidade de Investigação e Desenvolvimento em Engenharia Mecânica e Industrial – UNIDEMI, Faculdade de Ciências e Tecnologia of the University of New Lisbon (UNL), from Portugal. The authors wish to thanks for the support and assistance from both institutions.

References

Adams, R., Bessant, J., & Phelps, R. (2006). Innovation management measurement: A Review. *International Journal of Management Reviews*, 8 (1), 21-47. https://doi.org/10.1111/j.1468-2370.2006.00119.x

Amabile, T. M. (1998). How to kill creativity. *Harvard Business Review*, September–October 76 (5), 76-87.

Bagno, R., Salerno, M. S., & Silva, D. (2017). Models with graphical representation for innovation management: a literature review. R&D Management. 47. 637-653. 10.1111/radm.12254.

Bessant, J. & Phillips, W. (2013). Innovation management and dynamic capability. In: C. Harland, G. Nassimbeni, & E. Schneller (Eds.), The Sage Handbook of Strategic Supply Management: Relationships, Chains, Networks and Sectors, London: Sage, Edition 1st, Chapter 15, 353-372.

Birkinshaw, J. & Mol, M. (2006). How Management Innovation Happens. MIT Sloan Management Review, 47(4), pp. 81-88.

Bremser, W. G., & Barsky, N. P. (2004). Utilizing the balanced scorecard for R&D performance measurement. Research and Development Management, 34(3), 229–238. https://doi.org/10.1111/j.1467-9310.2004.00335.x

Callaghan, C. (2019). Rothwell's augmented generations of innovation theory: Novel theoretical insights and a proposed research agenda. South African Journal of Business Management, 50(1), 8 pages. doi:https://doi.org/10.4102/sajbm.v50i1.217

Cerezo-Narváez, A., García-Jurado, D., González-Cruz, M. C., Pastor-Fernández, A., Otero-Mateo, M., & Ballesteros-Pérez, P. (2019). Standardizing Innovation Management: An Opportunity for SMEs in the Aerospace Industry. Processes. 7(5):282. https://doi.org/10.3390/pr7050282

Cortimiglia, M.N., Delcourt, C.I.M., De Oliveira, D.T., Correa, C.H., & Danilevicz, Â. de M. F. (2015). A Systematic Literature Review on Firm-Level Innovation Management Systems. In Proceedings of the IAMOT 2015—24th International Association for Management of Technology Conference: Technology, Innovation and Management for Sustainable Growth, Cape Town, South Africa, 8–11, June 2015; pp. 1698–1713.

Cooper, R. G. (1994). Third-Generation New Product Processes. *Journal of Product Innovation Management,* 11(1), 3-14. https://doi.org/10.1111/1540-5885.1110003

Cooper, R. G. (2008). Perspective: The Stage-Gate®Idea-to-Launch Process—Update, What's New, and NexGen Systems. *Journal of Product Innovation Management,* 25(3), 213–232. https://doi.org/10.1111/j.1540-5885.2008.00296.x

Cormican, K., & O'Sullivan, D. (2000). *Developing a self-assessment audit to support product innovation management proceedings of the information and communication technology (ICT)*, in Logistics and Production Management Conference, Tromso, Norway.

Coutinho, P. L. de A., Longanezi, T., Bomtempo, J. V., & Pereira, F. M. A. (2006). *Construindo um sistema de gestão da inovação tecnológica: atividades, estrutura e métricas*. Presented to the XXIV Symposium on Technology Innovation Management, Gramado, Brasil.

Crossan, M. M., & Apaydin, M. (2010). A multi-dimensional framework of organizational innovation: A systematic review of the literature. Journal of management studies, 47(6), 1154-1191.

Damanpour, F., & Aravind, D. (2012). Managerial Innovation: Conceptions, Processes, and Antecedents. Management and Organization Review. 8. DOI:10.1111/j.1740-8784.2011.00233.x

Damodharan, S; Rao, A; Menon, S; Saha, S, (2022). Innovation Management Footprint in a Technology Organization, 2022 IEEE TECHNOLOGY AND ENGINEERING MANAGEMENT CONFERENCE (TEMSCON EUROPE), Proceedings Paper, APR 25-29, 2022, Izmir, TURKEY.

Donnelly, G. A. (2000). P&L for R&D. *CFO Magazine,* February, 44–50.

Espinosa-Cristia, J. F. (2019). Managing innovation based on studies on science, technology, and society: toward a constructivist and critical perspective of innovation management. *Cadernos EBAPE*, Rio de Janeiro, RJ: FGV, 17(1), 68-83. https://doi.org/10.1590/1679-395171625

Faria, A. F. (2018). O que é inovação, seus tipos, e como tal fenômeno relaciona-se com uma forte estrutura institucional para o desenvolvimento científico. In F. de M. Soares; and E. K. E. Prete (Eds.), *Marco regulatório em ciência, tecnologia e inovação: texto e contexto da Lei nº 13.243/2016*. Belo Horizonte: Arraes Editores.

Giménez Medina, Manuel & Domínguez Mayo, Francisco José & González Enríquez, José. (2022). A systematic review of capability and maturity innovation assessment models: Opportunities and challenges. Expert Systems with Applications. 213. 10.1016/j.eswa.2022.118968.

Hidalgo, A. & Albors, J. (2008). Innovation Management Techniques and Tools: A Review from Theory and Practice. R&D Management, 38, 113-127. http://dx.doi.org/10.1111/j.1467-9310.2008.00503.x

Howlett, M., Ramesh, M., & Wu, X. (2015). Understanding the persistence of policy failures: The role of politics, governance and uncertainty. *Public Policy and Administration,* 30(3-4), 209–220. https://doi.org/10.1177/0952076715593139

Hunter, D. J., McCallum, J., & Howes, D. (2018). Defining Exploratory-Descriptive Qualitative (EDQ) research and considering its application to healthcare. In Proceedings of Worldwide Nursing Conference 2018. http://nursing-conf.org/accepted-papers/#acc-5b9bb119a6443

Jacobsson, M., & Jałocha, B. (2021). Four images of projectification: an integrative review. *International Journal of Managing Projects in Business,* Emerald Publishing Limited, 14(7), 1583-1604. DOI 10.1108/IJMPB-12-2020-0381

Kaplan, R. S. (2003). Managing innovation, Balanced Scorecard Report, *HBS Publishing*, 5(1), 1-5.

Kitsuta, C. M., & Quadros, R. (2019). Gestão da inovação em empresas brasileiras de serviços de tecnologia da informação: modelos de inovação planejada, de aplicação rápida e de inovação deliberada a posteriori. *Cadernos EBAPE*, 17(4), 1048-1061. https://doi.org/10.1590/1679-395174440

Kruger, L. L.S.J., Pretorius, Jan H. C., & Erasmus, L. D. (2019). Towards a comprehensive systematic innovation model: A literature review. *SAIEE ARJ [online]*, 110(1), 39-46. https://doi.org/SAIEE.2019.8643149

Lilja, J., Hansen, D., Fredrikson, J., & Richardsson, D. (2017). Is innovation the future of quality management? Searching for signs of quality and innovation management merging, International Journal of Quality and Service Sciences, 9(3/4), pp. 232-240. https://doi.org/10.1108/IJQSS-03-2017-0024

Longanezi, T., Coutinho, P., & Bomtempo, J. V. M. (2008). Um modelo referencial para a prática da inovação. *Journal of Technology Management & Innovation,* 1(3). Santiago, Chile.

López-Mielgo, N., Montes-Peón, J. M., & Vázquez-Ordás, C. J. (2009). Are quality and innovation management conflicting activities?, 29(8), 0–545. doi:10.1016/j.technovation.2009.02.005

Martínez-Costa, M., Jimenez-Jimenez, D., & Castro-del-Rosario, Y.d.P. (2019), "The performance implications of the UNE 166.000 standardised innovation management system", European Journal of Innovation Management, Vol. 22 No. 2, pp. 281-301. https://doi.org/10.1108/EJIM-02-2018-0028

Mavroeidis, V., & Tarnawska, K. (2017). Toward a New Innovation Management Standard. Incorporation of the Knowledge Triangle Concept and Quadruple Innovation Helix Model into Innovation Management Standard. *Journal of Knowledge Economy* 8, 653–671. https://doi.org/10.1007/s13132-016-0414-4

Nielsen, M. (2012). Reinventing discovery. Princeton, NJ: Princeton University Press.

OECD. (1997). *The measurement of scientific and technological activities — Proposed guidelines for collecting and interpreting technological innovation data*, Oslo Manual, Paris. Second Edition.

Melendez, K., Dávila, A., & Melgar, A. (2019). Literature review of the measurement in the innovation management. Journal of Technology Management & Innovation, 14(2), 81-87. https://dx.doi.org/10.4067/S0718-27242019000200081

Pinheiro, C. G. R. (2018). *Gestão da inovação de uma empresa do setor de energia sob a perspectiva da Norma ABNT NBR*. Trabalho de Conclusão de Curso (graduação), Universidade Federal do Ceará, Curso de Engenharia de Produção Mecânica, Fortaleza.

Qureshi, T. M., Dar, I., & Khan, M. A. (2008). Innovation Management: Types, Management Practices and Innovation Performance In Services Industry of Developing Economies. Innovation and Knowledge Management in Business Globalization: Theory & Practice, Vols 1 and 2, 10th International-Business-Information-Management-Association Conference, JUN 30-JUL 01, 2008, Kuala Lumpur, Malaysia.

Riederer, J., Baier, M., & Graefe, G. (2005). Innovation management – an overview and some best practices. *Siemens Business Services*, California, 4(3), 1-58.

Rothwell, R. (1992). Successful industrial innovation: critical factors for the 1990s. *R&D Management*, 22(3), 221–240. http://dx.doi.org/10.1111/j.1467-9310.1992.tb00812.x

Roussel, P. A ., Saad, K. N., & Bohlin, N. (1991). *Third Generation R&D*. Arthur D. Little Inc, Harvard Business School Press.

Salerno, M. S., Proença, A., Carvalho, A. M. de, Oliveira, A. R. de, Danilevicz, A. de M. F., Silva, D. O. da, Vaccaro, G. L. R., Caulliraux, H. M., Pellegrin, I. de, Júnior, J. A. V. A., Gomes, L. A. de V., Pantaleão, L. H., Echeveste, M. E. S., Ferreira, M. A. T., Miguel, P. A. C., Clemente, R. G., Leis, R. P., Silva, S. M. da, & Gusberti, T. D. H. (2010). Gestão estratégica da inovação: Em busca do como fazer. In: V. F. de Oliveira, V. Cavenaghi, & F. S. Másculo (Eds.). *Tópicos emergentes e desafios metodológicos em engenharia de produção: casos, experiências e proposições* (Volume III): Rio de Janeiro, ABEPRO, 137-240.

Sánchez Ocampo, E., Iacono, A., & Leandro, F. R. (2019). Gestão da inovação em empresas de base tecnológica: um estudo de caso em empresas incubadas. *Innovar*, 29(74), 71-84. https://dx.doi.org/10.1159/000499853

Santa Soriano, A., Torres Valdés, R. M., & Magallón Pendón, S. (2017). Sinergias entre Relaciones Públicas e Inteligencia Estratégica: Estudio de procesos comunes entre modelos de RRPP y la especificación técnica TS16555-2 aprobada por el Comité Europeo CEN/TC389. Obra Digital. Revista De comunicación, Estudios mediáticos Y Procesos Sociales, (13), 13–35. https://doi.org/10.25029/od.2017.154.13

Schee Genannt Halfmann, S., Evangelatos, N., Kweyu, E., Devilliers, C., Steinhausen, K., Van Der Merwe, A., & Brand, A. (2019). The creation and management of innovations in healthcare and ICT: The European and African experience. *Public Health Genomics*, 21, 197–206. https://dx.doi.org/10.1159/000499853

Silva, A., & Dutra, A. (2021). Gestão de riscos no setor público: revisão da literatura internacional. Revista Brasileira de Administração Científica, 12(3), p.158-172. DOI: http://doi.org/10.6008/CBPC-2179-684X.2021.003.0013

Simon, A. & Honore Petnji Yaya, L. (2012), "Improving innovation and customer satisfaction through systems integration", Industrial Management & Data Systems, Vol. 112 No. 7, pp. 1026-1043. https://doi.org/10.1108/02635571211255005

Smith, P. G., & Reinertsen, D. G. (1992). Shortening the product development cycle. *Research-Technology Management*, 35(3), 44–49.
Steiber, A., & Alänge, S. (2013). A corporate system for continuous innovation: the case of Google Inc.. European Journal of Innovation Management, 16(2), 243–264. doi:10.1108/14601061311324566

Teece, D. J. (1986). Profiting from technological innovation: Implications for integration, collaboration, licensing and public policy. *Research Policy*, 15(6), 285–305. https://dx.doi.org/10.1016/0048-7333(86)90027-2

Tidd, J., Bessant, J., & Pavitt, K. (2005). *Managing innovation: integrating technological, market and organizational change*. 3rd Edition. Chichester, UK: John Wiley.

Tidd, J. (2021). A Review and critical assessment of the ISO 56002 Innovation Management Systems Standard: evidence and limitations. *International Journal of Innovation Management*, 25(01). doi:10.1142/S1363919621500493

Vilha, A. M. (2010). *Gestão da inovação nas empresas*. Cartilha, Plano de desenvolvimento setorial do plástico e da borracha. Prefeitura de Diadema, SP.

Von Bertalanffy, L. (1972). The History and Status of General Systems Theory. Academy of Management Journal, 15(4), 407–426. doi:10.5465/255139

Xu, Q., Chen, J., Xie, Z., Liu, J., Zheng, G., & Wang, Y. (2007). Total Innovation Management: A Novel Paradigm of Innovation Management in the 21st Century. The Journal of Technology Transfer. 32, 9-25. 10.1007/s10961-006-9007-x

Zaoui, S., Hamou-ou-Brahim, S. A., Zhou, H., Omrane, A., & Huang, D. (2021). Consumer purchasing behaviour towards strategic innovation management practices in Morocco during COVID-19 health crisis. FIIB Business Review, 10(2), 158-171.

Zen, A. C., Machado, B. D., López, A. I. J., Borges, M. C., & Menezes, D. C. de. (2017). Rota da inovação: uma proposta de metodologia de gestão da inovação. *Revista de Administração Contemporânea*, 21(6), 875-892. https://dx.doi.org/10.1590/1982-7849rac2017170151