

UNCERTAINTY MANAGEMENT IN INNOVATION ACTIVITIES

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Abstract

From a common reference framework on uncertainties, the project articulates four subprojects: 1) uncertainty management in major/radical innovation activities in established companies, focusing on issues of innovation organization and the emergence of an innovation function in the company, valuation and portfolio management of innovation projects, innovation processes, and (in)compatibility between short-term incentives to managers versus long-term horizons typical of major/radical innovation; 2) entrepreneurial action in startups focused on uncertainty management in the innovation ecosystem of value co-creation, and in the decision-making heuristics that shape entrepreneurial action; 3) legal and institutional uncertainties in technology contracts [research and development (R&D)], particularly between public and private actors; and 4) some systemic key uncertainties: public policies to support innovation in the company, and the new opportunities and threats regarding data analytics. Therefore, the project uses both qualitative and quantitative methodologies. Qualitatively, subprojects 1 and 2 adopt the methodology of longitudinal case studies, following the evolution of companies and their decisions over time; projects 3 and 4 analyze documents and interview actors. Quantitatively, surveys and analysis based on official databases. The project aims at contributing to the literature on innovation management, entrepreneurial action, organizational theory, and public policies. It articulates actions with leading researchers worldwide.

The project has direct-doctoral scholarships and funds for the research activity.

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1. PROBLEM STATEMENT AND RESEARCH QUESTIONS

The general research question structuring the project is: *how uncertainties can be perceived and managed in innovation activities, taking into account the aspects of innovation organization and management, contracts and public policies?* It brings together the discussions on radical innovation management, uncertainties in contracts, and public policies to boost innovation. These themes are articulated around the concept of uncertainty, which is a crucial concept in innovation and, more specifically, in radical innovation (RI) management. Based on Knight (1921), we differentiate uncertainty from risk through the impossibility of measuring or estimating the *a priori* probability of critical variables that affect the development of projects. Moreover, there might be unknown uncertainties at the beginning of a project, unforeseeable uncertainties¹, in the words of Schrader et al. (1993), Sommer and Loch (2004) and Loch, Solt and Bailey (2008) - i.e., uncertainties that will only be configured by efficiently and articulately following some courses of action based on aspects of the environment in general and the ecosystem in particular. Therefore, it is impossible to assign traditional indicators to uncertainties, and uncertainty management follows different paths than risk management. The project aims to discuss and improve the concept of uncertainty and its repercussions for managing radical innovation projects², emerging technology-based companies (spinoffs, startups), and technology contracts [particularly those between public and private entities (such as a university-company or a research support foundation-company)], taking into account the effects of uncertainties in public policies for

¹ “Inability to recognize the relevant influence variables and their functional relationships; thus, events and actions cannot be planned ahead of time” (SOMMER; LOCH, 2004, p.1334).

² Following a trend in literature, we are considering here as radical not only the very rare innovations that change the world, but also those innovations named as major (O'Connor, 2008), or strategic (Govindarajan and Trimble, 2005; O'Connor et al, 2018). Below, we will discuss the concepts of radical innovation and major/strategic innovation, relying on these authors.

innovation into companies, ecosystems, and projects. RI management is the primary axis that articulates the whole project since it is articulated with R&D and similar contracts that companies articulate to strengthen their innovation projects, and with public policies that induce directions and can reduce uncertainties and risks of the innovation activity. In that sense, we will discuss, and we aim to contribute to the knowledge and practitioners on the following themes: i) the management of major/radical innovations, including its organizational forms, its typical management tools and the problem of human resources management, since managers are evaluated by quantitative measured short-term results (e.g., year), although radical or substantive innovation is a long-term and full of uncertainties activity; ii) entrepreneurial action in the ecosystem and the decision heuristics implemented by entrepreneurs to cope with uncertainties. These two themes are central, and they are affected by issues rarely touched in engineering or business research: a) issues of legal and institutional insecurity in technology contracts. The aim is to contribute to the knowledge in these three fields by incorporating in each analysis a broader perspective (management, contracts, and policy). That is, innovation management, at a more strategic level, includes dealing with the institutional environment and public policies tools and induction. Additionally, there is the purpose of contributing to the institutional environment and with public policies.

Garcia and Calantone (2002) consider that radical innovations, defined as those that offer unique attributes in the world or significant performance improvements (5 times or more) in cost or other variables, are extremely rare. However, there is a set of innovations that involve technical or market discontinuities, but that would not fit in the strictest definition of RI. O'Connor (2008) refers to the latter group as major innovations, explaining that both types of innovations (i.e., both radical and major) have features that are not found in incremental innovations. Those features include high levels of uncertainty in multiple dimensions, implying that the company must operate in unknown territories, where current stocks of knowledge and consumer loyalty are not competitive advantages as exacerbated as they are in incremental innovations. Thus, when we refer to RI, we use a somewhat broader concept that also addresses major or more radical innovations. More radical innovations are particularly significant both in the Brazilian case and in the case of many developing countries with an industry linked to commodities or products that feature technological disruptions. Although, such innovations may not either constitute

significant market disruptions or “create” markets that did not previously exist³). It is the case for large established companies such as Aché, Braskem, Boticário, Cristália, Elekeiroz, Embraco, Mahle, Natura, Petrobras, Vale, Weg, among others.

A substantial amount of literature associates innovation of a more significant nature (i.e., major, radical innovation) with uncertainty (JALONEN, 2012; LOCH, SOLT; BAILEY, 2008; MCKELVIE et al, 2011, O’CONNOR et al, 2018). Therefore, major innovation management involves uncertainty management (LEIFER et al, 2000; LEIFER et al, 2001; PICH et al, 2002; SOMMER; LOCH, 2004; O’CONNOR et al, 2008; RICE e al, 2008; HOWELL et al, 2010; SALERNO et al, 2015). The management of emerging technology-based companies can also be seen from the perspective of uncertainty management (GOMES; SALERNO, 2010; SALERNO et al, 2015, GOMES et al, 2018). With regard to public policy and public-private contracts, the new ST&I (Science, Technology, and Innovation) legal code aims at mitigating uncertainties (which here are called “legal insecurity”); moreover, there are resource uncertainties, such as the lack of a perennial budget allocation for Finep – The Brazilian Innovation Agency (SALERNO, 2012).

For these reasons, the construct uncertainty is central to this project. The first characterization of the construct is made below and should be improved throughout the project. Such characterization is essential for us to define the framework that supports the research questions and the methodological approach.

Based on the systems approach (CHURCHMAN, 1971; ACKOFF, 1974), we might consider a set of environmental variables that exert a strong influence on both the decision to innovate and the extent of innovation programs. However, if we take the ecosystem approach (MOORE, 1993; ADNER, 2006; ADNER; KAPOOR, 2010; GOMES et al., 2016) as a basis, we find that even within a single company, different environmental aspects can have different types of influence on different projects or types of business. For example, there is evidence that public policies affect companies’ willingness to innovate, and particularly, the extent of their innovation, which in Brazilian companies, is directly related to the emergence of an innovation function (BAGNO et al., 2017). However, there is much discussion in forums such as Corporates’ Mobilization for Innovation (*Movimento Empresarial para Inovação - MEI*) about legal insecurities related to incentives and contracts, which has led entities such as ABDI (the Brazilian Industrial Development Agency) to hire an expert consultancy to determine the best

³ This is true in the initial cases of mobile phones, computers, smartphones, Post-its, and the Walkman; i.e., in cases in which it is impossible to define *a priori* what the market is.

institutional design for specific programs to support innovation and technological development, for example, in the case of aeronautical technology demonstration platforms (ABDI, 2014).

Following the trajectory of organizational theory, we adopt a contingency approach. In generic terms, contingency theory postulates that the best way to organize or manage an enterprise (project, portfolio, business, company) depends on a set of contingencies. Woodward (1965), Lawrence and Lorsch (1967), and Thompson (1967), among others, are dedicated to technology contingency and the differentiation and integration between internal functions of the company. Shenhar (2001), Andres and Zmud (2001), Shenhar and Dvir (2007), Kok and Biemans (2009), Sauser et al. (2009), and Eggers (2012), among others, question the single (one size fits all) approach to project management. The contingency approach is also found in the entrepreneurship field with respect to entrepreneurial action and the initial planning of startups, as in Vohora et al. (2004), Gomes and Salerno (2010), and even Sarasvathy (2001), who, even while defending the first construct, implicitly address effectuation and causation as creating possibilities for entrepreneurial action. Concerning innovation management, in research financed by Fapesp, Salerno et al. (2015) analyzed 132 innovation projects in 72 companies, defining eight types of innovation processes based on the contingencies that they confront.

A pillar of this project is the formation of a multidisciplinary team. The team includes researchers in production engineering, management, sociology, economy, and law. By multidisciplinary, we do not intend to adopt a generic approach that dilutes disciplines; instead, we intend to deepen our treatment of each subject by using team experts who dialogue with other disciplines. Thus, we will not seek generic syntheses that superficially contemplate the various specialties gathered here; instead, we intend for each specialty to be inspired, even if only in part, by the other specialties' development in a manner that helps each specialty enrich its own approach. At this stage of the division of scientific work, it would be difficult to suppose, for example, that legal research and publications are not created by legal researchers, and so on. What unites the researchers participating in this proposal are the pillars of the uncertainty and contingency approach, as applied to issues of innovation management and addressed from a variety of perspectives. Therefore, as set forth below, the project is broken down into subprojects (SP), each of them with their own specific theoretical and methodological approach, linked to the primary discipline (management, sociology/policy, and law) and goals.

Figure 1 shows the generic conceptual framework of the research. The themes of

innovation organization and management are affected by the uncertainties in the firm and the ecosystem and, more broadly, by legal and institutional uncertainties as well as uncertainties in public policies. The framework is deployed in three subprojects and a transversal approach that permeates all the subprojects.

Figure 1. Conceptual framework



Subproject 1. Radical innovation management in large companies: organizational project for the development of capabilities in radical innovation.

The central research questions⁴ guiding SP1 are: i) *How do large, established companies seek to equate the search for systematic radical innovation?* ii) *What are the emerging organizational roles in this quest?* iii) *What are the critical aspects (valuation, human resource policies, others) of this quest?* Propositions derived from these questions are depicted in item 3, above. SP1 is based on organizational theory (LAWRENCE; LORSCH, 1967; THOMPSON, 1967; O’CONNOR; DEMARTINO, 2006; O’CONNOR et al, 2008) and discusses the characteristics of “innovation function” in an emergency context (O’CONNOR, 2012; BAGNO et al, 2017) with the support of the dynamic capabilities theory (TEECE, 2007). The initial hypothesis is that the innovation function, being a type of networked function (i.e., a function whose essential resources for action must be articulated in a network), is not covered by current categories of organizational units. Such developments are made in cooperation with Gina O’Connor’s team at the Rensselaer Polytechnic Institute (RPI, Troy, NY, USA). One of the points raised in previous studies, and in line with the RPI research, is the (in)coherence between the search RI and human resource management systems. While major innovation projects usually mature in the long run (years, even decades), incentives for managers are short-term (year, months), even for senior managers (O’CONNOR; MCDERMOTT, 2004; CHOI et al, 2012; ROBENSON; O’CONNOR, 2013; CHOI et al, 2015; O’CONNOR et

⁴ The research question of all the subprojects will be detailed in the item 1.1.3 below.

al, 2018). This incoherence can slow down innovation, and it is the subject of item 1.1.

SP1 is deeply embedded in organizational theory. The primary methodological approach is the classic one in the field, that is, multiple case studies, based on Eisenhardt (1989) methodological issues. To overcome some of the restrictions of case studies, as the difficulty to get the diffusion of the investigated phenomena, we will proceed to surveys on specific issues, as highlighted in section 3 (“Overcoming Scientific and Technological Challenges”). The surveys have the aim to propitiate a broader panorama of the diffusion and the state of specific organizational modalities and management tools to check contingencies, scopes and limitations of aspects related to the emergence of the innovation function [organizational ambidexterity, relation to other functions like R&D, the relationship between R (Research), and D (development)] and the management system (forms of project valuation, portfolio management, portfolio segmentation, treatment of radical projects, and managerial incentives related to long-term innovation). Nevertheless, it is extremely promising to associate the discussion of innovation management with the company-level discussion of productivity and competitiveness improvements, inspired in works such as those by De Negri and Salerno (2005), De Negri and Kubota (2008), De Negri and Cavalcanti (2014), and Araújo and Salerno (2015). The surveys will also consider research questions of the other subprojects; this is one of the ways to integrate all subprojects.

Subproject 1.1 As noted above, the international literature begins to indicate a compatibility problem between short-term incentives to managers and long-term major innovation activities. Incentives shape behavior and should be aligned with company strategy (DAVILA et al, 2007; GALBRAITH et al, 2011). As stated by Choi et al, (s.d., p.1), “Organizational leaders routinely note the critical importance of human capital resources in enabling successful innovation outcomes. While the observation of their significance is important, human resource management (HRM) practices are not necessarily aligned with practices that positively affect breakthrough innovation (BI), where uncertainty, ambiguity, and risk of failure are high”. O’Connor and McDermott (2004), investigating 12 major players in RI showed that “In all but one firm, RI teams were compensated no differently from anyone else in the firm. Careers were sidelined by unsuccessful projects in some cases. Bonuses and promotions were dependent on project success. Given the low likelihood of success, the downside risk for engaging in radical innovation is very high” (p. 25).

Systems of HRM are an integral part of the management of a company. The inconsistency between an RI strategy and the human resource approach to RI managers may introduce many uncertainties in the system. Thus, SP1.1 will focus on discussing the attractiveness of careers in RI management and career uncertainties: do incentives induce short-term thinking, or are they compatible with the long horizons and uncertainties of major innovation projects? This will be developed with interviews, surveys and research within databases of publications like Forbes, “Melhores e Maiores” or “Valor Inovação” to get the trajectory of CEOs and proxies of the attractiveness of the career in innovation management – how many CEOs have had positions in substantive innovation management? A series of temporal data would be more elucidative than a single year.

Subproject 2: Uncertainty management in the innovation ecosystem: how entrepreneurs manage collective uncertainties in the ecosystem.

The literature on entrepreneurial action focuses on the enterprise itself; actions are related to a single company development (SARASVATHY, 2001; GOMES; SALERNO, 2010). New ecosystem approaches shed light on the co-creation of value among various actors (ADNER; KAPOOR, 2010; GOMES et al, 2016). This observation leads to a discussion of individual x collective uncertainties (those that affects more than one actor) and entrepreneurial action in the ecosystem (GOMES et al, 2018). An emerging entrepreneurship that involves either the creation (or development) of new markets or the development of new nontrivial technologies (or the nontrivial integration of relatively unconsolidated technologies) acts in an environment characterized by numerous uncertainties (SARASVATHY, 2001). Uncertainty management becomes critical to the enterprise’s success. However, such uncertainties occur not only in the company but also—and perhaps primarily—in the ecosystem. Here, the entrepreneurial action becomes an act of the management and mitigation of collective uncertainty, which involves more than one actor in an ecosystem. In previous research, case studies in Fapesp project 2009/04045-3, we realized that certain company actions, for example, pivoting (changing strategy, the technology route, etc., according to RIES, 2011), can create considerable uncertainties in the ecosystem, resulting in the leaving of some players. For example, this was the case of a startup that, while developing equipment (hardware and software), took an action that was rational from a purely internal point of view and pivoted, changing the operating system; this caused the actors who had developed applications based on the previous system to abandon the ecosystem, a move that the company did not resist.

Thus, the study of collective uncertainties in the ecosystem and the entrepreneurial action to manage them occurs is a central point, a conceptual gap that, if filled, can provide numerous contributions to both theory and practice. Accordingly, entrepreneurial action leads us to decision-making (CZASZAR; EGGERS, 2013) and heuristics. Heuristics can be described as cognitive shortcuts adopted by individuals when there is a restriction of time, information, and processing capacity (SIMON, 1965). Inspired by planning approaches through heuristics (EISENHARDT; SULL, 2001, BINGHAN et al, 2007), we can consider that the entrepreneurial action for managing uncertainties in the ecosystem occurs based on a set of heuristics built from situations they have faced.

The research questions here are: i) *Which strategies entrepreneurs utilize to realize (sensing) and act on collective uncertainties to promote their business and the co-creation of value by the ecosystem;* ii) *Which kind of heuristics entrepreneurs develop to make strategic decisions regarding value co-creation in the ecosystem.* The literature (including EISENHARDT; SULL, 2001, BINGHAN et al, 2007) proposes a typology of heuristics for large enterprises whose fundamental problem would be to determine the best options (among many) to capture value. However, a startup wrapped in an ecosystem has the initial goal of creating (or co-creating) value, and the typology proposed by the literature does not adhere well to this condition. We will work on a new typology.

The path on heuristics will lead to the discussions of micro-foundations of decision on entrepreneurial action – or in intrapreneurial action, as proposed by Foss and Pedersen (2014), an emergent research stream.

In-depth case studies are the primary methodology in subproject 2, as depicted below.

Subproject 3. Uncertainty and legal obstacles in R&D, technology, and innovation contracts

SP3 discusses legal and institutional aspects - mainly, although not exclusively, contractual ones—involving both public-private contracts and relations established between public entities (e.g., R&D institutes, universities) and only between private-sector organizations in the field of innovation. It is based on the premise that designing, structuring and articulating institutional arrangements and legal/contractual instruments among actors such as the state, companies, entrepreneurs, and universities are vital to trigger and foster innovation (CASSIOLATO; LASTRES, 2005). SP3 is also based on the assumption that in the Brazilian legal framework several institutional and intersectoral orchestration mechanisms are not fully institutionalized, and that new forms of

relationship between the state and the private sector have to be created from scratch, nurtured and disciplined. At the same time, the dynamic essence of innovation requires such existing legal and institutional arrangements to be both stable (to ensure investments in somehow risky and uncertain circumstances) and flexible (to allow adjustments and adaptations along the way and thus tackle contingencies), as noted by Coutinho and Mouallem (2015). Moreover, as Mazzucato (2013) and Block and Keller (2011) argue, it is critical to design contractual forms through which the gains and positive externalities resulting from innovation are captured not only by private agents but also by the state. The central underlying hypothesis is that in Brazil there are persistent and severe obstacles - from the viewpoints of system building and legal effectiveness - to overcome when it comes to the goals of innovation promotion. The current legal and national institutional framework is the result of an accumulation of legislation enacted in various historical contexts to satisfy various purposes and sectors, thus creating overlaps and regulatory ambiguities surrounding innovation activities. While assuming that uncertainty is also inherent to contracts, the project will focus on the understanding and mapping of how legal uncertainty represses or encourages interaction between the actors in an innovation system. Legal subsystems — tax, budgetary, financial, litigation or intellectual property, for example — are not to be identified and assessed separately. An integrated, transversal approach proves to be crucial to understanding better how several aspects of contracting innovation interact and ultimately hinder promising initiatives and ideas. Innovation in the real world does not adhere to fragmentary legal practices and segregated advices. In other words, from the angle of agents of innovation processes, innovative capabilities are affected by the whole of interfaces with regulatory mechanisms, government policies and contractual devices (OECD, 2005; 2012).

Brazilian public managers, officers, and entrepreneurs often find themselves perplexed and disoriented about how to employ legal tools or how to evaluate the (in)correctness of certain legal proceedings. Furthermore, despite recent progress - in part due to the enactment of the new version of the Innovation Law (13.243/2016) which draws more precise standards for the applications of existing rules and regulations -, public audit offices still promote an often-obtuse and formalistic interpretation of legislation, deviating from the public and private effort to promote innovation. This is the synthetic backdrop against which the state, companies, and institutes of S&T have been forced to develop their contractual (mostly long-term relational) activities, leading to economic relations affected by additional uncertainties.

Therefore, this subproject discusses the following research question: *which are the uncertainties concerning contracts on R&D, and how can they be surpassed?*

SP3 will be developed in two fronts. In the first place, we will focus on the analysis of the Brazilian legal-institutional framework (including statutes, regulations and administrative decisions) with the aim of identifying bottlenecks and constraints to contracts of R&D and innovation. Secondly, it will identify contractual obstacles - clauses, conditions, requirements, caveats and so on - which may directly or indirectly affect the parties' decision making under uncertainty. The research methods to be adopted will be detailed in the following section 3. SP3 is directly linked to the other SPs because legal and institutional frameworks are essential and indeed constitutive to innovation management and public policies. Among other relevant actors, incumbent and startup companies set their strategies and operations in accordance with a whole universe of possibilities, restrictions, and uncertainties governed by legal/contractual aspects.

Subproject 4: Systemic key uncertainties: public policies to support innovation in the company, and the new opportunities and threats regarding data analytics

SP4 focuses on two main issues: uncertainties in public policies (a Brazilian-oriented discussion) and uncertainties regarding the “pack” data analytics (big data, AI - artificial intelligence, IoT – internet of things and similar). SP4 is designed to support the others. At first glance, it does not present any specific research question to advance theory, moreover in public policies; it aids to understand uncertainties practitioners' sense, with a clear link with SP3 (legal – institutional uncertainties). AI and related technologies are emerging, and there are uncertainties on how to set appropriate business models to explore it⁵.

SP4 focus on the effects of such uncertainties in established companies, startups, and contractual relations – respectively, SPs 1, 2, and 3, and less centered on policies themselves. The so-called New Legal Code on Science, Technology and Innovation is in consolidation, what was not the case years ago. There is some literature on it, including papers from our team, that have improved the discussion (ARBIX et al, 2017). Regardless, it is entirely consensual that the inconsistency, stops-and-goes, and lack of confidence on the permanence, on the financial and political support of Brazilian innovation policies, result in uncertainties affecting current innovation activities as well

⁵ For instance, an interview with directors of Weg late 2017 revealed that the company is acquiring data via IoT but has not (yet) set an appropriate business model to explore it commercially.

as firm's willingness to engage on new ones. Whereas such inconsistencies are well discussed in the literature (Arbix et al, 2017; 2010; SALERNO, 2012; DE NEGRI; KUBOTA, 2008), it consists in uncertainties to be managed by incumbent firms and startups. Our emphasis is on the effects such uncertainties cause on innovation activities (SP1, 2) and in contractual relations (SP3); SP3 will provide theoretical analysis and propositions to approach the problem.

Our goal is twofold. First, to locate obstacles that hinder technological development and to find new points of contact that allow and facilitate the transit of intangible goods between the generation of innovation in companies and the production of new knowledge, especially in universities. Legal uncertainty permeates and directly interferes with Brazil's innovation environment, with negative impacts on both the overall investment system and the performance of funding and support agencies. The legal aspect has strong links with SP3. Second, to understand whether and how firms are searching to innovate their business through AI and correlated disruptive technologies.

In this vein, SP4 discusses the following questions: a) which are the uncertainties regarding public policies to boost innovation and how can they be surpassed? How are firms facing AI and similar technologies, how are they structuring business models to capture AI opportunities? The basic methodology is documental analysis and interviews with policymakers and companies' executives. The international network around the project can be an articulated aid in the discussion of such items. It is possible to have inputs from Colombia, Denmark, France, Germany, UK, and the USA.

1.1 On the Concept of Uncertainty

The expected contribution of this project is to determine how to confront, manage and unfold uncertainty, either in major or RI projects in large companies or startups, emerging technology-based companies and their ecosystems, or concerning legal-institutional issues and AI. Therefore, it imposes a conceptual discussion on uncertainty.

Radical innovation projects and emerging technology-based companies are shrouded in many uncertainties, including some that are not identified early in the project or enterprise. The same is true of innovation policies, which experience issues related to the budget, coordination, political views, adhesion by the target audience, etc., and of entities' contractual R&D relationships, particularly between public and private entities.

Initially, it will be necessary to develop a more robust conception of the construct uncertainty that subsidizes interpretative models for each of the themes set forth above.

In the traditional project-management literature, risk is the most widely used term. Often the definition of risk refers to the term “uncertainty,” although it is not defined what is meant by uncertainty, as in Aven et al. (2010). Even O'Connor and Demartino's (2006) definition of RI, which is set forth above, treats risk and uncertainty as self-explanatory terms. A more promising current to deepen the concept of uncertainty and characterize the difference between risk and uncertainty is found in Knight (1921). This author argues that risk relates to future events that occur with a probability susceptible to estimation, whereas uncertainty relates to events with an indefinite future probability that is impossible to calculate. The richness of this approach is that it allows us to associate uncertainty with a lack of information, insufficient information, cognitive issues and an inability to predict phenomena, variables, occurrence periods, and so forth. Galbraith et al (2011) relate uncertainty to the gap between the amount of information required to perform a task and the amount of information already possessed by the organization. In other words, more information would lead to less uncertainty. Sanderson (2012) considers risk to define a situation in which it is possible to assign objective probabilities to a set of future events, either based on known mathematical chances or empirical extrapolation of past events. Uncertainty is then defined by the inability to assign objective probabilities to a set of future events. This would involve considering the extreme hypothesis of cases in which neither nature nor the configuration of the set of future events, is known or susceptible to inference in advance. Liesch et al. (2011) associate uncertainty with the unknown future, which is not susceptible to calculation in advance.

Another point that has been criticized by various researchers relates to the potentially narrow focus of studies on entrepreneurship and strategy about uncertainties. Alvarez (2007) emphasizes that entrepreneurship research focus primarily on the influence of risk in decision making, paying less attention to the role of uncertainty. According to Knight (1921), Sarasvathy (2001) and Dew et al. (2009), entrepreneurs make more decisions under uncertainty than under risk. In addition, as claimed by Ward and Chapman (2003), some authors have considered only the negative aspect of uncertainty, either ignoring that uncertainty can be a source of opportunity (as suggested by McGrath and MacMillan (2000)) or fail to consider that uncertainties can be a source of value for projects, as argued by Huchzermeier and Loch (2001). Nevertheless, the literature seems to focus on incumbent firms, not considering the fact that entrepreneurial firms are part of a system (e.g., a value chain) or of an ecosystem (in a sense described by MOORE, 1993, ADNER, 2006 and ADNER; KAPOOR, 2010). As Lubik, Garnsey and Minshall (2012) argue,

entrepreneurs may be challenged to create and manage an ecosystem in which they can develop and commercialize an innovation.

Uncertainty management approaches tend to emphasize the dimensions firm and project, as is the case in Rice et al (2008), Loch et al (2008) and McGrath and MacMillan (2000). These types of studies devote less attention to the role of strategies that aim to equate the uncertainties present in the ecosystem. In this regard, Li and Garnsey (2011) highlight that adopting a collective perspective on the entrepreneurial action can provide a better understanding of how entrepreneurs create and capture value in the development and commercialization of RIs. Finally, Marino et al (2010) note that the relationship between a firm's performance, its partners (ecosystem) and the environment is a critical research gap in the field of entrepreneurship.

Thus, it is necessary to develop a typology of uncertainties and characterize them not only in a company or a specific project but also in the ecosystem.

1.1.1 Typology of uncertainties

Table 1 synthesizes an initial literature review on the dimensions of uncertainty set.

Table 1. Dimensions of uncertainty

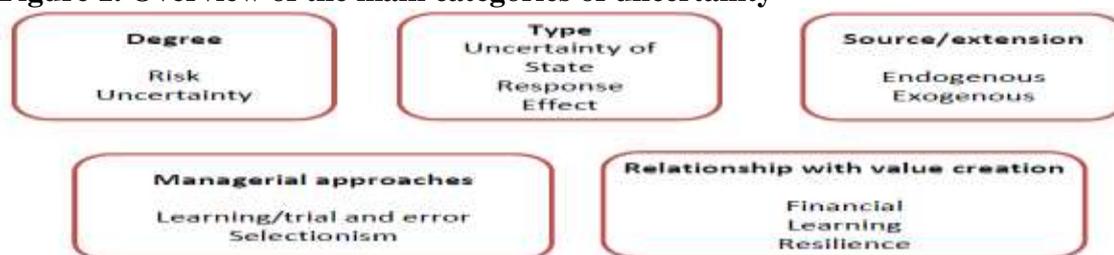
Dimension	Definition
Degree	Considers risk as the lowest degree of uncertainty. Risk is seen by Dequech (2000) as weak uncertainty.
Types	<p>Uncertainty of state: difficulty to predict how components of the environment will change (MILLIKEN, 1987).</p> <p>Uncertainty of effect: difficulty in predicting how changes in the environment will impact the firm (MILLIKEN, 1987).</p> <p>Uncertainty of response: difficulty in obtaining insight into the options of responses to a given change and predicting the consequences of each option (MILLIKEN, 1987).</p> <p>Procedural uncertainty: emerges from computational and cognitive limitations of the agents in the pursuit of their goals, even if information is available (DOSI; EGIDI, 1991)</p> <p>Unpredictable uncertainty: an inability to map all of the variables relevant to project performance (PICH; LOCH; MEYER, 2002).</p>
Area	<p>Areas of uncertainty, according to Rice, O'Connor and Pierantozzi (2008):</p> <p>Technological: uncertainties about technological aspects of innovation such as performance and functional characteristics, among others.</p> <p>Market: uncertainties about market aspects of innovation such as customer needs and market size, among others.</p> <p>Resources: uncertainties about whether the company will have the necessary financial resources and competencies, among other things, to develop and commercialize an innovation.</p> <p>Organization: uncertainties about the organizational, political and power structures, among other organizational issues related to the development and commercialization of radical innovation.</p>
Extent and source	Extension implies the number of actors affected by uncertainty (DIXIT et al., 1994). Source: uncertainty is internal or external to either the firm (when the reference is the firm) or the ecosystem.

Management approach	Learning by trial and error; selectionism (SOMMER, LOCH, 2004); causation and effectuation (SARASVATHY, 2001).
Relationship with value creation	Uncertainty can increase the value of an innovation project if learning and managerial flexibility are considered.

Source: prepared by the team, articulated by Leonardo Augusto de Vasconcelos Gomes.

Let us note that aspects of improvisation and effectuation are proposed by Sarasvathy (2001) for emerging enterprises and are more closely linked to how to approach the planning because it is argued that the entrepreneur must act instead of spending his limited resources (time, money, people) engaging in formal planning. Thus, the graphical overview in Figure 1 covers the main categories of uncertainty that will support the beginning of the project. Of course, the bibliographic and the field research may suggest either the addition of new categories or the reworking of the categories presented here.

Figure 1. Overview of the main categories of uncertainty



1.1.2 Innovation ecosystem approach

Ecosystem is a term popularized by Moore (1993) as a metaphor to render explicit the interdependence between actors in businesses marked by the challenges of innovation. The formalization of the construct has advanced. Adner and Kapoor (2010) consider that understanding a firm's performance in an innovative environment requires an approach that makes explicit not only the innovation challenges a firm faces itself but also the challenges about the nature of innovation experienced by external partners. Additionally, it is essential to extend the focus to understand how various actors will compete to capture the value created. Nevertheless, those authors suggest that technological and market challenges, along with their associated uncertainties, must be addressed in the ecosystem with partners to ensure the innovation's commercial success. Similarly, we might consider that uncertainties can be created, propagated and amplified in the ecosystem, requiring coordinated action to confront or take advantage of them.

Thus, instead of exclusively using the contours of the firm or sector (industry), we will also use the concept of ecosystem as the space in which uncertainties are created, transmitted, amplified, mitigated and taken advantage. By extending the contour of the firm to the ecosystem, contractual and public policy issues also take shape.

1.1.3 Research questions

Under these conditions, the central research question (*how uncertainties can be perceived and managed in innovation activities, taking into account the aspects of innovation organization and management, contracts and public policies?*) is deployed in the following ones:

- ❓ How can uncertainty be more accurately defined, taking as a backdrop radical innovation management and the management of startups? Conceptual accuracy is pursued here, which is simultaneously something in itself (contributing to the improvement of key concepts) and a necessary condition to develop the next questions. The aim is to improve knowledge on how to cope with uncertainties in the ecosystem.
- ❓ How do large established companies seek to equate the search for radical innovation? What are the organization's roles that emerge in this pursuit? This an open question; literature is suggesting the emergence of a new function (as Finance, Manufacturing, Marketing, etc.), the innovation function (IF), but it is not clear the formats IF assumes.
- ❓ Is the emergence of an innovation function configuring a new type of organizational function, the networked function? What are the critical aspects (evaluation, people management policies, others) of this pursuit? These are open questions in the literature; the hypothesis of the networked function is, to our knowledge, new, and can be a tremendous theoretical contribution.
- ❓ How does the entrepreneur act in situations of uncertainty? How does he/she seek to take advantage of the collective uncertainties in an ecosystem? Here we are opening a new theoretical approach based on our concept of collective uncertainties.
- ❓ What are the types of heuristics used by entrepreneurs to manage uncertainties in the ecosystem? This question is fundamental to a more consistent approach to uncertainty management and the management of both radical innovation and emerging technology-based enterprises. It improves the knowledge of entrepreneurial action; literature does not have propositions on it; it only states that entrepreneurs utilize heuristics instead of optimization or traditional ("Porter-like") planning models.
- ❓ What are the uncertainties in contractual relations related to R&D and major innovation between public and private entities, between public and public entities and between private and private entities, and what are the legal and regulatory alternatives to mitigate them? Which institutional-legal or infra-legal framework to surpass these uncertainties? These questions have a high impact on legal literature and on practice,

since if equated, suggestions can be made to improve legal-institutional rules.

- ❓ What are the uncertainties related to political policies for supporting innovation, and how do agents perceive them? Which directions to overcome current uncertainties to have policies that are more effective? The newness is to consider public policies as uncertainty, what adheres not only to Brazilian panorama. We expect contributions to public policies, synthesized in papers.
- ❓ How companies are approaching AI and correlated technologies, how are they trying to build competencies and business models on the subject? This is an exploratory question, not yet approached in the literature.

2. EXPECTED RESULTS

We expect to make a significant contribution to both theory and the practice of managers, entrepreneurs, policymakers and legal professionals, with the results disseminated in qualified scientific journals, scientific meetings, several disclosures, and books. We also expect to engage in discussion activities and general disclosure, particularly in seminars of the Observatory of Innovation and Competitiveness, IEA-USP, which will be transmitted live over the Internet (IPTV-USP) with videos available for consultation on the OIC portal (<http://oic.nap.usp.br>).

We expect to make the following contributions:

- ❖ Identification of the main conceptual approaches to uncertainty in major/radical innovation projects, taken here as product innovation or processes of major innovation. There is a gap in the formalization of uncertainty.
- ❖ Creation of a typology of uncertainties—characteristics, dimensions, that support the operationalization of the concept.
- ❖ Characterization of entrepreneurial actions related to collective uncertainties in the ecosystem. Identification of how different actors address uncertainties and how they seek to mitigate them, amplify them or take advantage of them by disseminating them. That is, contributing to a theory of entrepreneurial action in the ecosystem.
- ❖ Provision of a typology of decision heuristics in entrepreneurial action. There is a lack in the literature since current typologies (BINGHAM; EISENHARDT, 2011; BINGHAM; EISENHARDT; FURR, 2007) are related to incumbent firms trying to capture value, but there is not on creating value.
- ❖ Characterization of the innovation function (IF), and testing the networked function hypothesis, which states that IF is assuming a different configuration in comparison to

traditional organizational functions (like Production, Marketing, Finance, etc.), that is, assuming a networked form. Traditional functions directly control the resources they need to perform and delivery – e.g., Production has buildings, machines, workers, energy, raw materials. IF does not have the resources, it has to borrow them internally or, in addition, to get them outside the company, acting in a network. Apart from the concept of networked function, another theoretical contribution is the proposal of a formal concept (rigorous definition) of organizational function; surprisingly, there is no such definition in the organizational literature.

- ❖ Analysis of the coherence among Human Resource policies, incentives to managers and RI. That is, testing the hypothesis that standard HR policies for managers are short-term and are not adequate for incentivizing, evaluating and compensating management and executives' careers concerning RI.
 - ❖ Characterization of uncertainties in agreements, contracts, and other instruments that have the execution of R&D activities as their object or that aim to promote innovation between public and private entities, accompanied by analysis and proposals related to legal and regulatory improvement in the field of innovation. We also aim to provide support for predictability in decision making by ST&I managers.
 - ❖ To present proposals to improve the quality of public policies to boost innovation.
- The thematic project proposes to contribute both to knowledge (literature), practice, and public policies. With the support of NAGI (*Núcleo de Apoio à Gestão da Inovação*, Poli-USP & partners, financed by Finep, Call for Proposals “Pro-Inova”) and the support of the NAP-OIC, we expect to provide the following contributions to practice:
- ❖ Support for entrepreneurs through the proposal of mechanisms to identify and mitigate collective uncertainties in the ecosystem.
 - ❖ Support for the constitution and improvement of innovation processes and organization for major/radical innovation in large companies.
 - ❖ Mechanisms to mitigate uncertainties in contracts and public-private arrangements of R&D and major/radical innovation.
 - ❖ Proposal to improve public policies that incentivize innovation by identifying both the actors' uncertainties and the most effective instruments. A set of proposals to reduce uncertainties in advanced manufacturing policies.
 - ❖ A less tangible result would be to work with high-quality, international scientific teams to establish a permanent interdisciplinary discussion that leverages academic production and attracts students. The project is articulated with top scholars working

with the theme in Brazil and abroad (see the initial network in section 4, page 28).

3. OVERCOMING SCIENTIFIC AND TECHNOLOGICAL CHALLENGES (METHODS)

The primary scientific challenge that combines each of the proposals formulated as subprojects is to understand the phenomena related to major innovations with a view towards advancing both knowledge in general and the tools for companies (Brazilian, mainly) to increase and improve innovation. Each subproject has its own scientific and methodological challenges. SP1, and to some extent SP2, articulates directly with SPs 3 and 4. All SPs focus on understanding how to improve innovation, either by creating new knowledge on organization and management issues or by sensing the key points to overcome in the legal-institutional framework and public policies.

Although these subprojects have a common conceptual background—uncertainty and uncertainty management—each SP has its own specificities. That means that we will be confronted with different methodological approaches. The project is multidisciplinary, and each discipline has its own trajectory and its own methods of development. For instance, it is of utmost importance to have longitudinal (along years) in-depth case studies to investigate the emergence and the shaping of the characteristics of the Innovation Function; similar methodology is applied to subproject 2. Surveys complete the scenario to surmount the limitations of case studies, making it possible to have a boarder panorama of the phenomena. On the other hand, subprojects 3 and 4 are based on documental analysis; interviews complement it by capturing perceptions, problems, and ideas on how to cope with them. Surveys aid to capture perceptions, problems and the move of the actors along the time.

Two procedures to assure that interdisciplinarity will contribute to the conceptual deepening of each of the disciplines: i) in the empirical data gathering of each project there will be questions of the other projects (respectively, innovation management, public policy, and juridical-institutional analysis). For instance, in the project on innovation management, we will ask companies on the effects of public policies and juridical aspects on their innovative activity. Similarly, in subprojects on policy and on juridical-institutional issues, we will ask about how each of these issues generates uncertainties for the management of innovation in the company, or in the innovation ecosystem. ii) team discussions on the empirical evidence of each subproject, on the sources of uncertainty and on how companies articulate their management system to cope with them.

A draft of the initial research protocols is attached in Sage system – Documents / Other Documents/file “Research Protocols,” with 32 pages, 7.274 words. Although it exemplifies how data is to be collected, it is too large to be exposed here.

In the following section, we will organize the discussion by subprojects.

Subproject 1. Radical innovation management in large companies: organizational project for developing radical innovation capabilities.

Basic scientific challenge, research questions, and propositions

The characterization of the emerging IF - innovation function (O'Connor, 2012) passes through the most rigorous definition of organizational function; this is expected to be a theoretical contribution. By characterization we mean the description of what IF is, which mandate, which resources, which roles people perform inside IF. One primary challenge is the verification of the networked function hypothesis (an institutional arrangement not described in the literature), synthesized on proposition 1A. Both questions are to be worked with RPI's Radical Innovation Group.

Proposition 1A). There is the emergence of a new organizational function to cope with more radical innovations – the innovation function (IF). The innovation function assumes the format of a networked function, not the form of a traditional function that controls the resources IF needs to deliver what the function is expected to. It involves the analysis of the coherence and relevance of systems (e.g., Davila et al, 2007, Galbraith et al, 2011) associated with the innovation function, particularly portfolio management and human resource (HR) systems and manager bonuses (with RPI's Radical Innovation Group), and valuation/portfolio management in more radical innovation projects.

Proposition 1B). More radical projects require deeper ambidexterity not only to isolate portfolios (as in strategic buckets) physically but to separate them organizationally and managerially. It means strong strategic intent, different criteria for different portfolios, different people to decide resources allocation (to avoid cannibalization of radical projects towards incremental ones, what we have seen in the preliminary investigation).

Proposition 1B1). Derived from proposition 1B, at least the initial phases [discovery and incubation according to O'Connor et al (2008)] of radical projects, when they are involved in many uncertainties, radical innovation portfolios must be a task of the C-level of the organization (VP, directors, depending on the company), while in incremental projects C-level is only asked to decide on substantive investments, as to expand facilities. RI requires craft management, not mass management.

Proposition 1B2). Valuation of projects in initial phases (discovery, incubation) cannot be done in financial terms since there is no available data. Firms have to imply other tools – adherence to strategy, valuation by learning, by achieving milestones.

Proposition 1C) Human Resource systems are not adherent for RI managers that deal with long-term uncertain projects. HR systems are based on short-term. In the same way that employs different HR systems for blue and white collars, they should apply different HR systems for RI managers, based on learning instead of earning.

We propose a methodology that is both qualitative and quantitative, comprising both surveys and case studies, with longitudinal characteristics (monitoring over time). Although the qualitative method is hegemonic in studies on innovation management, articles derived from quantitative surveys are increasing in the literature on innovation management and the evaluation of public policies (the theme of subproject 4).

We have discussed with Anpei⁶ to make possible to conduct surveys with its associates; other Industrial Associations are being contacted for the same proposal. Surveys will be conducted in different moments; scholarships demanded accordingly: A) before the beginning of case studies and interviews. In that sense, surveys aid in the preparing of qualitative research. B) In the second/third year, in parallel with qualitative research, to get aggregate information or to confirm some questions arisen in interviews/case studies. If we manage to get CNPJ (company's national register number) of the respondents and a sufficient number of respondents (to cope with IBGE requirements), we can discuss with IBGE and Ipea to associate our results with microdata processing in association with the databases with the large national databases (Pintec - Innovation, PIA/PAS – economic and financial data for industry and services, RAIS – information of workers, wages, Secex-MDIC – external trade, BC – credit and financial operations, MPOG – Governmental Procurement). The methodology for the simultaneous use of these databases can be seen in De Negri et al. (2005) and was used in several studies, such as De Negri and Salerno (2005), Arbix, Salerno and De Negri (2005), and Araújo and Salerno (2015). Such kind of microdata processing is feasible because of the cooperation agreement we have with IPEA (see document attached).

One of the considered restrictions of home-made surveys like those is the difficulty in expanding the sample to the whole universe – only with an extensive and costly survey, compatible with IBGE sample standards could solve this problem. However, such a

⁶ National Association of R&D of Innovative Companies. Conversations already started.

solution is not feasible at the moment.

There will be specific surveys for specific themes, involving all subprojects. Surveys for startups have unique features treated in subproject 2 below.

The research question on the (in)coherence between uncertainty and long-term involvement in RI projects x human resource policy will also be addressed by a quantitative study, in different years. As highlighted in the discussion of subproject 1.1, page 9, based on the list of major companies and most innovative companies get from publications as Fortune, Forbes, Fast Company, *Melhores e Maiores*, *Valor Inovação*. For each company we search on the internet on the trajectory of the CEO; a preliminary search showed us that most companies have press releases with a short bio and the career of the CEO. LinkedIn is another source to get CEOs trajectory. By classifying trajectories of CEOs, we would be able to have the percentage of them with a background in R&D or innovation – a proxy of the attractiveness of a career in innovation management.

The central method for the whole project is qualitative – that is, the project can be sustained by interviews, case studies, and documental analysis if the surveys return no sound data. The qualitative approach is based in the traditional method applied by O'Connor and Demartino (2006), Clark and Wheelwright (1993), Cooper et al (1997, 2002), Clark and Fujimoto (1991), Salerno et al. (2015, resulting from a FAPESP aid) and numerous other studies in the field of organization and management - multiple case studies. Eisenhardt (1989), Yin (2014), Voss, Tsiriktsis and Frohlich (2002) and Miguel (2007) considered case studies one of the best options for management research. Admitting the emergence of the phenomena under investigation in SPs 1 and 2, it is necessary to conduct longitudinal case studies, following companies over several years based on the approach of Van de Ven and Poole (1990) and Van de Ven and Huber (1990), as used, for example, by O'Connor et al. (2008). Longitudinal case studies mean to research the company a long time to capture the evolution of emerging phenomenon. It is the method utilized by the most important studies on innovation management, as the works by Van de Ven and O'Connor. For instance, the RPI team is following a panel of companies since 1998; we are following some companies since 2008.

Eisenhardt (1989) and Eisenhardt and Graebner's (2007) precept should be observed: i.e., studies should be carried out until there are saturation and repetition of the results. Similarly, it is necessary to keep the triangulation precept (VOSS et al, 2002; MIGUEL, 2007) to control and minimize distortions (THIOLLENT, 1980).

In SP1 field research follows a double approach: depending on the subject, the research

unit is the company or the project. The initial focus is to understand general features of the company: strategy, a general management system for innovation, structure, departments (organizational functions), processes for incremental innovation, project valuation, portfolio(s) management, HRM. However, as a strategy to triangulate and control distortions (“official discourse”) when the company is the research unit, we will also focus on selected innovation projects, following their trajectory along time, as in Salerno et al (2015). This procedure permits to have a general vision of the innovation management system and to capture how this system is adapted, changed or by-passed in the surge of radical projects. Therefore, the research unit will be the innovation project itself, recovering the decision-making process and using it to discuss how uncertainties have been mapped, articulated and managed. For instance, by investigating decisions, articulations, and sources of resources in a given project, we aim to gather evidence to discuss the proposition of innovation function as a networked function.

The weight on the whole company or in projects depends on the subject. For instance, to discuss the proposition of networked function we need to look at the entire company to understand questions as organizational ambidexterity, departments, mandates forms of integration among departments, which no longer requires the innovation project as a unit of analysis. Instead, here the organization becomes a unit of analysis because the organization function is primarily established to perpetuate efforts to seek RI, thus mitigating organizational and resource uncertainties, according to O'Connor et al. (2008). However, by investigating real projects a long time, we get more evidence on the real operation of the function, with uncertainties that emerge along the time, and actions to face them. A similar approach to investigate the relationship between R and D when they are different departments, and to investigate the proposition of deep ambidexterity of portfolios to cope with radical innovation projects. The methodology for these latter themes on organization is similar to those utilized by Salerno (1999, 2009), Leifer et al (2000), O'Connor et al (2008) and many others. Research protocol here is based on the capture of work division and work coordination (LAWRENCE; LORSCH, 1967; MINTZBERG, 1993, GALBRAITH et al, 2011) in the interviewing process and documental analysis.

Therefore, in the field study, we will investigate one or more innovation projects that have already developed or are under development to grasp the uncertainties in which it is involved according to the type of uncertainty defined in the conceptual review. As seen above, this may involve not only the firm but also partners and external institutions.

The protocols of the field research are too long to be described here. The initial protocol to investigate portfolio management is described in the file *CARTA AOS REFEREES* attached in Fapesp's Sage system (*Outros documentos anexados*). Other protocols are annexed in the Sage system, file "Research Protocols". Item 9 (Work Plan for Scholarships) shows initial versions of other protocols for specific themes as portfolio management for radical innovation, innovation as a networked function, typology of heuristics for value creation, micro-foundations of entrepreneurial action, management of human resources for radical innovation. The schedule of the project predicts protocols refinement as initial activities.

Subproject 2: Uncertainty management in the innovation ecosystem: how entrepreneurs manage collective uncertainties in the ecosystem; decision heuristics concerning uncertainty management and strategic pivoting

Basic challenge, research questions and propositions

Here, we characterize entrepreneurial action in the ecosystem, not just in the firm; discuss the literature's current limitations; entrepreneurial action as action on uncertainties in both the firm and the ecosystem; and the problematics of Sarasvathy's (2001) and subsequent conceptions on effectuation as a hegemonic criterion to explain the entrepreneurial action. The fundamental research questions are i) *Which strategies entrepreneurs utilize to realize (sensing) and act on collective uncertainties to promote their business and the co-creation of value by the ecosystem;* ii) *Which kind of heuristics entrepreneurs develop to make strategic decisions regarding value co-creation in the ecosystem.*

The propositions that structure SP2 are listed below. Further details available at item 9 - workplan for scholarships:

Proposition 2A) Uncertainty management must encompass the ecosystem (collective uncertainties), not only firm specific uncertainties.

Proposition 2B) In a complex ecosystem (several actors), all uncertainty faced by the leading firms can be characterized as collective uncertainty.

Proposition 2C) Entrepreneurs develop heuristics to perceive opportunities, but also to perceive and act to mitigate collective uncertainty. The project aims to describe and classify such heuristics, including those related to how do entrepreneurs evaluate and select radical innovation projects.

Proposition 2D) The typology of heuristics by Bingham and Eisenhardt (2011) are not

adequate to value creation in startups; we aim to improve such typology.

The most prominent challenge is methodological and involves both capturing the decisions and revealing the underlying heuristics. The conceptual supports are listed in topic 1, in association with the works that characterize strategy as simple rules (EISENHARDT; SULL, 2001) related to decision heuristics (BINGHAM et al, 2007, BINGHAM; HALEBLIAN, 2012). The method of longitudinal case studies will be used, as stated in SP1. The general methodological precepts follow those recommended by Eisenhardt (1989), Yin (2014), Voss, Tsikriktsis and Frohlich (2002) and Miguel (2007) for case studies. In the case of startups, triangulation should be made to other actors involved in the ecosystem. The first case studies can feed surveys to get the sense of the extent of some phenomena, to test a typology of heuristics for entrepreneurial action, and test approaches and tools used for entrepreneurs to manage uncertainties in the ecosystem. Surveys here are based on Fapesp database on nascent companies that are participating or have participated in Pipe Program⁷, USP, Unicamp, UFRJ and UFMG incubators, accelerators, complemented by snowball procedure to get other startups.

The unit of analysis is the innovation project in the startup, based on which the decisions made will be surveyed, along with the events and contingencies involved in them, with emphasis on the pivoting decisions (in the sense of Ries, 2011). By interviewing entrepreneurs, we analyze the initial trajectory of the firm to capture decisions like pivots in strategy, search for resources, and similar decisions. This approach is also applicable when the events are happening and was already tested (FREITAS, 2016, GOMES et al, 2018). Thus, the startups' actions and decisions related to their strategic orientation will be monitored, seeking both a typology of decision heuristics and an understanding how entrepreneurs perceive, articulate and seek to mitigate uncertainties in the ecosystem—thus, the reason for longitudinal case studies over several years, connected to retrospective research, given that although it is impossible to research all phenomena from the moment they arise, it is possible to follow its evolution. Therefore, it will be sought to survey the trodden path with the entrepreneur in a kind of grounded research (O'CONNOR; DEMARTINO, 2006), focusing on how entrepreneurs perceive and act on uncertainties in the ecosystem.

Subproject 3. Uncertainty and legal obstacles in R&D, technology and innovation contracts

⁷ Available at <http://www.bv.fapesp.br/pt/3/pesquisa-inovativa-em-pequenas-empresas-pipe/>.

Basic challenge and research questions

SP 3 has different nature from 1 and 2. Here, we characterize uncertainties in the articulation of contractual relations and coordinate them with the existing legal and institutional framework, discarding purely commercial and similar obstacles; map legal “bottlenecks” to innovation in Brazil and discuss concrete cases involving public-private relations, instruments and contractual clauses, mechanisms for measuring and mitigating risks and uncertainty with the aim of ensuring predictability and legal security; and identify previously selected companies’ contractual practices related to R&D, technology and innovation, including more sensitive and critical issues that somehow entail costs and/or additional uncertainties and thus inhibit the development of innovative activities.

From the perspective of the theoretical framework, the adopted approach is of economic law and public policies and is based on the functional analysis of legal, infra-legal and contractual instruments, along with existing institutional arrangements and their implications for the effectiveness of public policies for innovation (COMPARATO, 1965; GRAU, 2000; COUTINHO, 2013; BRUCE et al, 2017). It is also supported by surveys and interviews with actors (companies, public ICTs, legal professionals, and the legislative and executive branches) about the difficulties and obstacles related to hiring, implementing and executing. These obstacles are analyzed based on the law. The research also uses a comparative approach, analyzing the solutions to critical problems in the national context, comparing with successful international experiences in innovation.

From the applied perspective, SP3 applies a qualitative method of research with a descriptive and exploratory nature. It will be conducted in three stages: (i) bibliographical review: literature research on uncertainty, innovation law, R&D and innovation contracts and innovation systems; (ii) document analysis: classification of contracts, including, but not limited to, identification of the parties, object, responsibilities and risks, applicable legislation and other legal instruments used for the actors’ interaction in the National Innovation System; and (iii) interviews: based on semi-structured questionnaires, interviews will be conducted with ST&I managers in public and private entities.

Subproject 4. Systemic key uncertainties: public policies to support innovation in the company, and the new opportunities and threats regarding data analytics

Basic challenge and research questions

SP4 is designed as a support to the others. It has a transversal character, that is, all SPs have questions on public policies and new issues related to data analytics. Uncertainties

in public policies have a different nature from those that arise in the creation of new business models relate to new technology, and from the technology itself. Therefore, there must be two different kinds of questions, as a) *which are the uncertainties regarding public policies to boost innovation and how can they be surpassed?* b) *How are firms facing AI and similar technologies, how are they structuring business models to capture AI opportunities?* The basic methodology for uncertainties in public policy is documental analysis and interviews companies' executives and managers, as well as public officials and policymakers. Concerning data analytics, the basic methodological approach is documental and literature review and interviews with companies' executives. We have already performed several studies concerning public policies for innovation, and there are specific forums for such discussions with the participation of researchers linked to the project, forums like MEI and Anpei committees. We have done some preliminary interviews on data analytics, as the mentioned interviews at Weg. The international network around the project can be an articulated aid in the discussion of such items. It is possible to have inputs from Colombia, Denmark, France, Germany, UK, USA.

4. PRINCIPAL INVESTIGATORS AND THEIR RESPONSIBILITIES

The principal investigator and the main investigator are articulated both thematically and methodologically through the activities of the Center for Research Support (*Núcleo de Apoio à Pesquisa - NAP*) the Observatory of Innovation and Competitiveness (*Observatório da Inovação e Competitividade*) of the Institute of Advanced Studies of the University of São Paulo (IEA-USP).

- Mario Sergio Salerno, Full Professor, Polytechnic School, USP (Poli-USP), Department of Production Engineering, is the principal investigator. He has participated in research projects and published in all of the proposed themes - Gomes et al (2018, 2016), Arbix et al (2017), Salerno et al (2015), Salerno (2015), ABDI (2014), CGEE (2014), Salerno (2012), Salerno et al (2011), Arbix et al (2010), Salerno et al (2010), Salerno (2009). He is responsible for the whole project, and particularly in SP1 and SP2, that is, for the investigation of uncertainty management in companies/startups.
- Diogo Rosenthal Coutinho, the co-principal investigator, is Associate Professor, Law USP, Department of Economic, Financial and Tax Law. He is responsible for SP3 and 4, involving legal-institutional questions, including public policies.

To cope with the challenges, we have articulated the following initial team of researchers.

Associate investigators (State of São Paulo):

Glauco Arbix, Full Professor, Sociology USP. Subprojects 3, 4.

Demétrio Gaspari Cirne de Toledo, Lecturer, UFABC. SP4.

Eduardo Senzi Zancul, Lecturer, Poli-USP, Dept. Production Engineering. SP 1,4.

Leonardo Augusto de Vasconcelos Gomes, Lecturer, FEA-USP. SP 1,2.

Luciana Onusic, Lecturer, Unifesp EPPEN—Osasco. SP 1.1.

Roberta de Castro Souza Pião, Lecturer, Poli-USP, Dept Production Engineering. SP1.

Sergio Luís da Silva, Associate Professor, UFSCar, Information Science. SP1.

Simone Vasconcelos Ribeiro Galina, Associate Professor, FEARP - USP. SP1.

Post-docs initially involved

Rogério Lacerda, Lecturer at UFSC Business School. Uncertainty management in the innovation ecosystem. SP2.

Maria Carolina Foss, lawyer and Ph.D. in scientific and technological policy (IG-Unicamp). Uncertainties in contracts for R&D and innovation. SP3.

Simone de Lara Teixeira Uchôa Freitas, Ph.D. in engineering (USP). Heuristics of strategic decision in emerging technology-based enterprises. SP2.

Ana Paula P. L.Barbosa, Ph.D business (USP). Cooperative projects in innovation. SP1,2.

Graduate students initially involved:

Rafael A. S. R. de Paula, Ph.D student. Organizational structures for IF. SP 1.

Vinicius C. Brasil, PhD student. RI portfolio management. SP1.

Frederico César V. Gomes, Ph.D student. Heuristics of entrepreneurial action. SP2.

Felipe P. Maranzato, Ph.D student. The relation between R (research) and D (development) – integration mechanisms. SP 1.

Felipe Massami Maruyama, Ph.D student. Acceleration of startups. SP 2, 4.

Pryscilla A. Vaz de Oliveira, Ph.D student. HR policies x innovation management. SP1.1.

Jaime Frenkel, Ph.D student. Innovation function & surveys with Anpei. SP1,3,4.

Julio Cezar F. de Melo, Ph.D student. Innovation function. SP1.

Lidyane Barros, Ph.D student. Processes of social innovation. SP1,2

Luiz Fernando C. S. Durão, Ph.D student. AI & advanced manufacturing. SP1,4.

Karyn Martinelli Silva, Ph.D. student. Design thinking. SP1,2.

João Vitor Nunes Leal, Ph.D student. Systems for IF to borrow resources. SP1.

Ricardo F. Paixão, Ph.D student. Startups incentives as innovation policy: an institutional diagnosis. SP3, 4.

Murilo Roberto J. Maganha, PH.D student. Knowledge management and flexibility. SP1.

Edivaldo Alberto Bolsan, Ph.D student. Work organization. SP1.

Pedro S. B. Mouallem, MSc student. Regulatory and contractual issues. SP 3.

Alexandre Ferreira, MSc student. Regulation of fintechs. SP3.

Gabriel Delage e Silva, MSc student. Medical product creation and development. SP1,2.

Rafaela F. Maniçoba, MSc student. Sensemaking of collective uncertainties. SP2.

Cristiane Matsumoto, MSc student. Business models for data analytics. SP4.

Alejandra Flechas Chaparro, MSc student. Pivot and uncertainty management in the innovation ecosystem. SP2.

Raul Cabral, undergraduate student. Social returns of BNDES action: the Criatec fund and technological innovation leveraging economic development. SP3.

Articulation with teams from other centers in Brazil

In association with this project, the following individuals and institutions will be submitting projects to their FAPs, Capes or CNPq, in line with this proposal.

Ana Valéria Carneiro Dias, Associate Professor, UFMG, Production Engineering Department and Post-graduate Program in Technological Innovation and Intellectual Property. Issues involving people and careers in RI. SP1.1.

André Ribeiro de Oliveira, Associate Professor, UERJ's Department of Industrial Engineering. Indicators of R&D and innovation in a company. SP1.

Maicon Gouvêa de Oliveira, Associate Professor, Federal University of Alfenas, Institute of Science and Technology, Poços de Caldas - MG. Technology management in large companies. SP1.

Raoni Barros Bagno, Associate Professor, DEP/UFMG and UFMG's Post-graduate Program in Technological Innovation and Intellectual Property. The emergence of the innovation function in large companies. SP1.

Jonathan Simões Freitas, Associate Professor, CEPEAD-FACE-UFMG (Post-graduate Program in Business Administration). Strategy and technology. SP1.

Ipea—Institute of Applied Economic Research (*Instituto de Pesquisa Econômica Aplicada*), particularly in the treatment of microdata surveys and quantitative surveys.

Investigators involved initially: Fernanda De Negri, Ph.D. in economics, former Director of Ipea; João Alberto De Negri, Ph.D. in economics, former Director of Ipea and Finep; Bruno Cesar Araújo, economist, Ph.D. in production engineering, Vice-Director. There is a formal partnership with Ipea (documentation attached). Microdata: all subprojects;

main focus: subproject 4.

Articulation with teams from foreign centers

Gina Colarelli O'Connor, Babson College, Boston, USA. O'Connor runs the Radical Innovation Research Program. Along with the principal investigator, she was in Brazil in 2013 (Finep funding), and the principal investigator has already been with her in the US (Fapesp research scholarship, 2014-2015), acting on the themes of innovation functions and careers in radical innovation management.

J.P. Eggers, Associate Professor of Strategy at NYU (New York University) Stern School of Business, interacting with Mario Sergio Salerno and Vinicius Chagas Brasil (who went to a doctoral stage at NYU in 2017, Capes sponsorship).

Elisabeth Garnsey, Professor and Senior Researcher, Institute for Manufacturing, University of Cambridge, UK, working with the principal investigator (Mario Sergio Salerno) and Leonardo Augusto de Vasconcelos Gomes on the theme of innovation ecosystems and uncertainty management in the ecosystem.

Sir Mike Gregory and team for The Babbage Industrial Policy Network, University of Cambridge, UK, including Eoin O'Sullivan and Carlos Lopez Gomes. Prof. Salerno participates at the network (see www.ifm.eng.cam.ac.uk/research/brg).

Elisabeth Reynolds, Professor and Researcher, MIT Industrial Performance Center, working with Mario Sergio Salerno (principal investigator) and Glauco Arbix. She has been to Brazil at least twice, and both of us have been at MIT with her. Theme: public policies for innovation.

Jacob Brix, Lecturer, University of Aalborg Business School, Denmark. Theme: Radical innovation management and HR management.

Alexandra Eugenia Arellano Guerrero, Lecturer, National University of Colombia. Theme: management of startups under uncertainty.

5. SCHEDULE

The project is scheduled to last for five years (10 semesters). The length is justified given the adopted longitudinal approach, which is particularly crucial for the discussion of innovation management, as set forth above.

Progress can be measured by the events listed below, both for the project as a whole and for its subprojects. The annual reports and the final report are not listed here: once mandatory, they become part of milestones and events. We will not list the phases of bibliographic research because they are obvious and based on the initial reference

framework, the ongoing evolution of knowledge and publications requires constant updating and revision; an integrated spreadsheet can be seen in topic 10.

General

General planning—a document with a specified reference term (for the project as a whole and each subproject) → 1st semester

Conceptual reference framework → 1st semester

Consult with the Council → 2nd, 4th, 6th, 8th and 10th semesters

Open seminars → all semesters

Submission to conferences, prioritizing those detailed in section 5

Annual submission of articles to several target journals, depending on the subproject, including Technovation, Academy of Management Journal, Journal of Business Venturing, Technological Forecasting and Social Change, Research Policy, Strategic Management Journal, Industry and Corporate Change, R&D Management, Journal of Engineering and Technology Management, IEEE on Technology Management.

Subproject 1

Methodological definitions: formalization of the research protocol (subprojects 1 and 1.1) to support the team's collective action; scripts, field procedures, standardized registration forms for field activities and surveys in general → 1st semester, with a review during the 2nd semester after pre-tests.

Pre-tests, reformulation of the instruments. Record of pre-tests → 1st/2nd semesters

Longitudinal case studies, according with the research protocol → 1st - 9th semesters

Definitions concerning the first survey: detailed reference term, methodological procedures, tabulation and delivery → 2nd semester

Analysis of the first survey; discussion with Associations → 3rd semester

Definitions of thematic surveys → semesters 3rd – 8th

Conduction of surveys along with Associations → 4th - 8th semester

Analysis of the surveys → (n or n+1)th semester

Visiting researcher's visit—Gina O'Connor (RPI) → 4th semester

Visiting researcher's visit—J.P. Eggers (NYU) → 6th semester

Disclosure activities and formalization of the submission of texts, as explained in the general part of the timetable.

Subproject 2

Methodological definitions: formalization of the research protocol to lay the foundation for the team's collective action; scripts, field procedures, standardized registration of field

activities and surveys in general → 1st semester, with a review at the 2nd semester, after pre-tests

Pre-tests and reformulation of the protocol → 1st/2nd semesters

Case studies, longitudinal follow-up → 1st/2nd - 9th semesters

Visiting researcher's visit—Elisabeth Garnsey (IfM) → 2nd semester

Disclosure activities and formalization of the submission of texts, as explained in the general part of the timetable.

Subproject 3

Organization of the current and relevant legislation—selection of laws and legal and infralegal instruments → 1st/2nd semester

Systematization of contracts and other legal instruments → 2nd semester

Systematized interviews → 3rd - 7th semesters

Organization of the findings—summary of the document analysis and interviews → 2nd - 7th semesters

Subproject 4

Definition of the research protocols → 2nd semester

Surveys – policy, contracts, AI → 2nd - 5th semesters

Interviews → 2nd - 8th semesters

Analysis: how uncertainties in contracts and innovation policy affect innovation management; how companies are facing data analytics, which business models.

6. DISSEMINATION AND EVALUATION

The project includes traditional scientific publishing (articles and books, particularly in qualified stratum), conferences (for peer validation) and broader disclosure to society through seminars, texts in newspapers, and interviews. The targeted scientific conferences are the Academy of Management (USA), Strategic Management Society (USA), IAMOT, Globelics, PICMET (variable cities and countries, dates idem). The proposal is to make several submissions annually to force the team to formalize its advances in an academic format, thus facilitating subsequent publication. There are several targeted journals, depending on the sub-theme, including Technovation, Academy of Management, Journal of Business Venturing, Administrative Science Quarterly, Technological Forecasting and Social Change, Research Policy, Industry and Corporate Change, R&D Management, Journal of Engineering and Technology Management, IEEE on Technology Management. The seminars of the Observatory of Innovation and

Competitiveness, which are broadcast live over the Internet, along with an event collection accessible in its library (<http://oic.nap.usp.br>), have proven to be very effective for disclosure. The project also includes more applied disclosure through discussion with companies, public support agencies, and professionals discussing legal frameworks for innovation.

Moreover, mixing disclosure and governance, we plan to set up a steering committee whose composition would be as follows: Carlos Américo Pacheco (former Rector of ITA, former MCT); Rafael Navarro (Braskem, director of the Anpei); Edmundo Aires (Petrobras, former VP of Technology at Braskem, former CO IPT), Fernanda De Negri (Director of the IPEA) the President of Anpei, Gina O'Connor (RPI, USA), and Guilherme Lima (ex-Whirlpool, former director of Anpei). They will be invited once the project is approved.

7. OTHER SUPPORTS

The project articulates additional financial support and non-financial institutional supports. The file “Explicação de Outras Fontes”, available at Sage System – Outros Documentos, details these supports. Internationally, the National University of Colombia will provide funds for the interchange of researchers and field research in selected local companies (document attached – Sage site). Gerpisa International Network (gerpisa.org) finances meetings of its Scientific Committee; though this finance, we have already developed field research in some companies in Europe, and we will keep on doing that. The University of Cambridge finances meetings to discuss public policies for innovation (The Babbage Industrial Policy Network), bringing together top researchers on the topic from Europe, US, Japan, and Korea – we are the only participant from Latin America. These meetings aid in international comparisons and are also extensible for some field research. Gina O'Connor (RPI, Babson College) will support travels in Massachusetts and New York States for field research through the project she is managing.

One member of the project's network, Prof. Bagno (UFMG) got funds for a postdoc period at the RPI in 2019, to perform theoretical and field research on the organization for RI. Prof. Dias (UFMG) has a similar project with the University of Bordeaux. Ipea contributes with air tickets and daily expenses for microdata processing at IBGE and BC (Fed). Additionally, there are Capes and CNPq scholarships and finance for post-docs abroad.

In economic terms, the Institute of Advanced Studies provides a disclosure team (as does

the Polytechnic School), rooms for events that will be broadcast live over the Internet, video recording and editing staff, and support in general, according to the document attached to the Sage system. Similarly, there is support from the Institute of Applied Economic Research (*Instituto de Pesquisa Econômica Aplicada*—IPEA) through the covenant from IPEA-Proredes call 01/2011 (see the attached documentation and letter of support from the Director of Sectorial Studies and Policies on Innovation, Regulation and Infrastructure), which enables technical exchange on databases and econometric methodologies for microdata processing, such as RAIS, Pintec, Central Bank (“FED”). There is also a project on Lean R&D (R\$723.000,00), financed by P&D ANEEL / ISA-CTEEP and coordinated by Prof. Eduardo Zancul with synergies that make it possible to supplement funding for this thematic project. The project finances microcomputers for students’ use, expenses for participation in scientific congresses, meetings in Brazil and Colombia.

Other projects have a contribution. A project funded by the USP (through the Dean of Research) created the Centers for Research Support (*Núcleos de Apoio à Pesquisa*—NAP), which supports the activities of the NAP Observatory of Innovation and Competitiveness (OIC), including both human and financial resources (an administrative support team and interns who built both OIC and LGI websites and integrated library). NAP’s overall project involved R\$ 750,000.00, executable by Professor Salerno and intended for convening discussion and disclosure events and paying travel expenses and daily expenses for researchers from outside the state of São Paulo. A project financed by ABDI on innovation policies, coordinated by Professor Arbix (2016-7), funded travels for surveys and documentary research abroad in Germany, China, and the USA. It is the basis for international comparisons. The thematic project also benefits from synergic integration with Peiex project funded by Apex. Coordinated by Prof. Salerno, the current agreement has the goal to provide services to 1,400 SMEs in the State of São Paulo; the overall budget (from 2011 on) is R\$14,259,999.06. Through the Nagi-Finep project, which ended in 2016, support was articulated with USP (Cietec), Unicamp and UERJ incubators. Discussions were initiated with Anpei for supporting the surveys.

Researchers from other states are articulating support in their FAPs and projects, such as NAGI-Finep. Support documents are attached (Sage site, “*Outros Documentos*”).

The file “*Explicação de Outras Fontes*,” annexed to Sage system, tab “*Outros Documentos*,” details other supports, which accounts, in financial terms, for R\$ 1.601.773,24, not including Gerpisa’s finance to travels and meetings.

8. BIBLIOGRAPHY

- ABDI. *Plataformas demonstradoras tecnológicas aeronáuticas: experiências com programas internacionais, modelagem funcional aplicável ao Brasil e importância da sua aplicação para o país*. Brasília: ABDI, 2014.
- ACKOFF, R. L. *Redesigning the future: systems approach to societal problems*. New York: John Wiley & Sons, 1974.
- ADNER, R. Match your innovation strategy to your innovation ecosystem. *Harvard Business Review*, v.84, n.4, p. 98-107, 2006.
- ADNER, R.; KAPOOR, R. Value creation in innovation ecosystems: how the structure of technological interdependence affects firm performance in new technology generations. *Strategic Management Journal*, v.31, p. 306-333, 2010.
- ALVAREZ, S. Entrepreneurial rents and the theory of the firm. *Journal of Business Venturing*, v.22, n.3, p. 427-442, 2007.
- ANDRES, H. P.; ZMUD, R. W. A contingency approach to software project coordination. *Journal of Management Information Systems*, v.18, n.3, p.41-70, 2001.
- ARAÚJO, B.; SALERNO, M. S. Technological strategies and learning-by-exporting: the case of Brazilian manufacturing firm. *International Business Review*, v.24, p.725-738, 2015.
- ARBIX, G.; SALERNO, M. S.; DENEGRI, J. O impacto da internacionalização com foco na inovação tecnológica sobre as exportações das firmas brasileiras. *Dados*, v.48, n.2, p.395-442, 2005.
- ARBIX, G; SALERNO, M. S.; TOLEDO, D.; MIRANDA, Z.; ALVAREZ, R. R. *Inovação: estratégia de sete países*. Brasília: ABDI, 2010.
- ARBIX, G.; SALERNO, M. S.; AMARAL, G.; LINS, L. M. Avanços, equívocos e instabilidade das políticas de inovação no Brasil. *Novos Estudos*, v.36, n.3, p.9-27, 2017.
- AVEN, T. On how to define, understand and describe risk. *Reliability Engineering and System Safety*, v.95, p. 623-631, 2010.
- BAGNO, R. B.; SALERNO, M. S.; DIAS, A. V. C. Innovation as a new organizational function. *Production*, v.27, p.1-13, 2017.
- BAGNO, R.B.; SALERNO, M.S.; SILVA, D.O. Models with graphical representation for innovation management: a literature review. *R & D Management*, v.47, n.4, p.637-653, 2017.
- BINGHAM, C. B.; EISENHARDT, K. M. Rational heuristics: the ‘simple rules’ that strategists learn from process experience. *Strategic Management Journal*, v.32, p.1437-1464, 2011.
- BINGHAM, C. B.; EISENHARDT, K. M.; FURR, N. R. What makes a process a capability? Heuristics, strategy, and effective capture of opportunities. *Strategic Entrepreneurship Journal*, v.1, p. 24-47, 2007.
- BINGHAM, C. B.; HALEBLIAN, J. How firms learn heuristics. *Strategic Entrepreneurship Journal*, v.6, n.2, p. 152–177, 2012.
- BLOCK, F.; KELLER, M. R. *State of Innovation: the U.S. Government’s role in technology development*. Boulder: Paradigm Publishers, 2011.
- BRUCE, J.R.; FIGUEIREDO, J.M.; SILVERMAN, B.S. *Public contracting for private innovation: government capabilities, decision rights, and performance outcomes*. Duke University / University of Toronto, Fev.2017. NSF Grants 1061600/ 1443014.
- CASSIOLATO, J. E.; LASTRES, H. M. M. Sistemas de inovação e desenvolvimento: as implicações de política, *São Paulo em Perspectiva*, v.19, n.1, 2005.
- CGEE – Programa demonstrativo para inovação em cadeia produtiva selecionada: indústria

- aeronáutica brasileira. Brasília: CGEE Série Doctos Técnicos, n.21, 2014.
- CHOI, B.; O'CONNOR, G. C.; RAVICHANDRAN, T. Navigating a risk-averse culture: the effect of strategic human resource management practices on breakthrough innovation (BI) in large firms. RPI: Troy (USA). Preliminary paper, 2015. (Accessed in Troy, during period financed by Fapesp - BPE – Dec.14 –Jan15).
- CHOI, B. C.; O'CONNOR, G. C.; RAVICHANDRAN, T. The effect of human capital management practices on breakthrough innovation. *Proceedings*, PDMA International Conference, Orlando. 2012.
- CHURCHMAN, C. West. *Introdução à teoria dos sistemas*. Petrópolis: Vozes, 1971.
- CLARK, K. B.; WHEELWRIGHT, S. C. *Managing new product and process development: text and cases*. New York: The Free Press, 1993.
- CLARK, K. B.; FUJIMOTO, T. *Product development performance: strategy, organisation and management in the world auto industry*. Boston: Harvard Business School Press, 1991.
- COMPARATO, F.K. O indispensável direito econômico. *Revista dos Tribunais*, v.353, p.14-26, 1965.
- COOPER, R. G.; EDGETT, S. J.; KLEINSCHMIDT, E. J. Optimizing the Stage-Gate process: what best practice companies do. *Research Technology Management*, v.45, n.5, p.21-27, 2002.
- _____. Portfolio management in new product development: lessons from the leaders - I. *Research Technology Management*. v.40, n.5, p. 16-28, 1997.
- COUTINHO, D. R. *O direito nas políticas públicas*. In: MARQUES, E.; FARIA, M. A. P. (Orgs.). *A política pública como campo multidisciplinar*. São Paulo/Rio de Janeiro: Editora Unesp e Editora Fiocruz, p. 181-198, 2013.
- COUTINHO, D. R.; MOUALLEM, P. S. B. *Gargalos jurídico-institucionais à inovação no Brasil*. In: *Direito Econômico Atual*. São Paulo: GEN/Método, 2015.
- CZASZAR, F.A; EGGERS, J.P. Organizational decision making: an information aggregation view. *Management Science*, v.59, n.10, p.2257-2277, 2013.
- DAVILA, T.; EPSTEIN, M.; SHELTON, R. *As regras da inovação*. Porto Alegre: Bookman, 2007.
- DE NEGRI, J. A.; CAVALCANTI, L. R. *Produtividade no Brasil: desempenho e determinantes*. Brasília: ABDI, IPEA, 2014.
- DE NEGRI, J. A.; FREITAS, F.; COSTA, G.; SILVA, A.; ALVES, P. *Tipologia das firmas integrantes da indústria brasileira*. Brasília: Ipea, 2005.
- DE NEGRI, J. A.; KUBOTA, L. C. *Políticas de incentivo à inovação tecnológica no Brasil*. Brasília: Ipea, 2008.
- DE NEGRI, J. A.; SALERNO, M. S. (Orgs). *Inovações, padrões tecnológicos e desempenho das firmas industriais brasileiras*. Brasília: Ipea, 2005.
- DEQUECH, D. Fundamental uncertainty and ambiguity. *Eastern Economic Journal*, v.26, n.1, p. 41–60, 2000.
- DEW, N. Serendipity in entrepreneurship. *Organization Studies*, v.30, p.735–53, 2009.
- DIXIT, A. K.; PINDYCK, R. S.; DAVIS, G. A. *Investment under uncertainty*. Princeton: Princeton University Press, 1994.
- DOSI, G.; EGIDI, M. Substantive and procedural uncertainty: an exploration of economic behaviour in changing environments. *J. of Evolutionary Economics*, v.1, n.2, p.145-168, 1991.
- EGGERS, J. P. All experience is not created equal: learning, adapting, and focusing in product portfolio management. *Strategic Management Journal*, v.33, p.315-35, 2012.
- EISENHARDT, K. M. Building theories from case studies. *The Academy of Management Review*, v.14, n. 4, p. 532-550, 1989.
- EISENHARDT, K. M.; GRAEBNER, M. E. Theory building from cases: opportunities and

- challenges. *Academy of Management Journal*, v.50, n.1, p. 25-32, 2007.
- EISENHARDT, K. M.; SULL, D. N. Strategy as simple rules. *Harvard Business Review*, v.79, n.1, p. 106–116, 2001.
- FOSS, N.; PEDERSEN, T. Micro foundations in strategy research: a virtual special issue of the SMS journals. *Strategic Management Journal*, v.37, n. 13, Dec.2014.
- FREITAS, S.L.T.U. Tipologia de heurísticas para a criação de oportunidades empreendedoras por startups. 2016. PhD Dissertation - Escola Politécnica da USP, PPGEP, São Paulo, 2016.
- GALBRAITH, J.; DOWNEY, D.; KATES, A. *Projeto de organizações dinâmicas*. Porto Alegre: Bookman, 2011.
- GARCIA, R.; CALANTONE, R. A critical look at technological innovation typology and innovativeness terminology. *Journal of Product Innovation Management*, v.19, n.2, p.110–132, 2002.
- GOMES, L.A.V.; SALERNO, M.S. Modelo que integra processo de desenvolvimento de produto e planejamento inicial de *spin-offs* acadêmicos. *Gestão&Produção*, v.17, n.2, p. 245-255, 2010.
- GOMES, L. A. V.; SALERNO, M. S.; PHAAL, R.; PROBERT, D. R. How entrepreneurs manage collective uncertainties in the innovation ecosystem. *Technological Forecasting and Social Change*, 2018.
- GOMES, L.A.V.; FACIN, A.L.F.; SALERNO, M.S.; IKENAMI, R.K. Unpacking the innovation ecosystem construct: evolution, gaps and trends. *Technological Forecasting & Social Change*, ah. of print, 2016. doi 10.1016/j.techfore.2016.11.009
- GOVINDARAJAN, V.; TRIMBLE, C. *10 rules for strategic innovators: from idea to execution*. Boston, Harvard Business School Press, 2005.
- GRAU, E. R. *Ordem econômica na constituição de 1988*. 5ª ed. São Paulo: Malheiros, 2000.
- HOWELL, D.; WINDHAL, C.; SEIDEL, R. A project contingency framework based on uncertainty and its consequences. *International Journal of Project Management*, v.28, p. 256-264, 2010.
- HUCHZERMEIER, A.; LOCH, C. Project management under risk: using the real options approach to evaluate flexibility in R&D. *Management Science*, v.41, n.1, p.85-101, 2001.
- JALONEN, H. The uncertainty of innovation: a systematic review of the literature. *Journal of Management Research*, v.4, n.1, 2012.
- KNIGHT, F. H. *Risk, uncertainty and profits*. Boston: Houghton Mifflin, 1921.
- KOK, R.A.W.; BIEMANS, W.G. Creating a market-oriented product innovation process: a contingency approach. *Technovation*, v.29, n.8, p. 517-526, 2009.
- LAWRENCE, P. R.; LORSCH, J. W. Differentiation and integration in complex organizations. *Administrative Science Quarterly*, v.12, n.1, p. 1-47, 1967.
- LEIFER, R.; MCDERMOTT, C. M; O'CONNOR, G. C.; PETERS, L. S.; RICE, M.; VERYZER, R.W. *Radical innovation: how mature companies can outsmart startups*. Boston: Harvard Business School Press, 2000.
- LEIFER, R.; O'CONNOR, G. C.; RICE, M. P. Implementing radical innovation in mature firms: the role of hubs. *Academy of Management Executive*, v.15, n.3, p. 102-113, 2001.
- LI, J. F.; GARNSEY, E. *Entrepreneurship and global health: catalyzing the ecosystem*. Univ. of Cambridge, Centre for Tech. Management Working Paper Series, 2011.
- LIESCH, P. W.; WELCH, L. S.; BUCKLEY, P. J. Risk and uncertainty in internationalization and international entrepreneurship studies. *Management International Review*, v.51, n.6, p. 851-873, 2011.
- LOCH, C. H.; SOLT, M. E.; BAILEY, E. M. Diagnosing unforeseeable uncertainty in a new venture. *Journal of Product Innovation Management*, v.25, p. 28-46, 2008.
- LUBIK, S.; GARNSEY, E.; MINSHALL, T. Beyond niche thinking: market selection in

- science-based ventures. In: Technology Management for Emerging Technologies (PICMET). Vancouver, *Proceedings*, p.785-789, 2012.
- MARINO, L.; KRESIER, P.; ROBINSON, A. Environmental uncertainty and firm-level entrepreneurship. In: LANDSTROM, H.; LOHRKE, F. (Eds.), *Historical Foundations of Entrepreneurship Research*, p. 81-97. Cheltenham: E. Elgar, 2010.
- MAZZUCATO, M. *The entrepreneurial state*. London: Anthem Press, 2013.
- MCGRATH, R. G.; MACMILLAN, L. *The entrepreneurial mindset*. Boston: Harvard Business School Press, 2000.
- MCKELVIE, A.; HAYNIE, M. J.; GUSTAVSSON, V. Unpacking the uncertainty construct: implications for entrepreneurial action. *Journal of Business Venturing*, v.26, p. 273–292, 2011.
- MIGUEL, P. A. C. Estudo de caso na engenharia de produção: estruturação e recomendações para sua condução. *Produção*, v.17, n.1, p. 216-229, 2007.
- MILLIKEN, F. J. Three types of perceived uncertainty about the environment: state, effect, and response uncertainty. *Academy of Management Review*, v.12, n.1, p. 133-43, 1987.
- MINTZBERG, H. *Structure in fives: designing effective organizations*. Englewood Cliffs (NJ): Prentice-Hall, 1993.
- MOORE, J. F. Predators and prey: a new ecology of competition. *Harvard Business Review*, May 1993. In: <http://blogs.harvard.edu/jim/files/2010/04/Predators-and-Prey.pdf>
- O'CONNOR, G. C. Innovation: from process to function. *Journal of Product Innovation Management*, v.29, n.3, p. 361-363, 2012.
- O'CONNOR, G. C. Major innovation as a dynamic capability: a systems approach. *Journal of Product Innovation Management*, v.25, p. 313-330, 2008.
- O'CONNOR, G.C.; CORBETT, A.C.; PETERS, L.S. *Beyond the champion: institutionalizing innovation through people*. Stanford: Stanford Univ. Press, 2018.
- O'CONNOR, G.C.; DEMARTINO, R. Organizing for radical innovation: an exploratory study of the structural aspects of RI management systems in large established firms. *J. of Product Innovation Management*, v.23, n.6, p. 475-97, 2006.
- O'CONNOR, G. C.; LEIFER, R.; PAULSON, A. S.; PETERS, L. *Grabbing lightning: building a capability to breakthrough innovation*. São Francisco: John Willey&Sons, 2008.
- O'CONNOR, G. C.; McDERMOTT, C. M. The human side of radical innovation. *Journal of Engineering and Technology Management*, v,21, p. 11-30, 2004.
- OECD – Organization for Economic Cooperation and Development. Governance of innovation systems: synthesis report. V.1, OECD Publishing: Paris, 2005.
- _____. Innovation for Development: a discussion of the issues and an overview of work of the OECD Directorate for Science, Tech. and Industry. OCDE: Paris, 2012.
- PICH, M.; LOCH, C.; MEYER, H. A. On uncertainty, ambiguity and complexity in project management. *Management Science*, v.48, p. 1008-1023, 2002.
- RICE, M.P; O'CONNOR, G.C.; PIERANTOZZI, R. Implementing a learning plan to counter project uncertainty. *MIT Sloan Management Review*, v.49, n.2, p.53-62, 2008.
- RIES, Eric. *The lean startup*. New York: Crown, 2011.
- ROBENSON, D.; O'CONNOR, G. C. Boards of directors, innovation, and performance: an exploration at multiple levels. *Journal of Product Innovation Management*, v.30, n.4, p.608-625, 2013.
- SALERNO, M. S. L'industrie brésilienne en situation paradoxale. VELTZ, P.; WEIL, T. (Eds.) *L'industrie, notre avenir*. Paris: Eyrolles/La Fabrique de l'Industrie, 2015.
- _____. Inovação tecnológica e trajetória recente da política industrial. *Revista USP*, n.93, p. 45-58, 2012.
- _____. Reconfigurable organisation to cope with unpredictable goals. *International Journal of*

- Production Economics*, v.122, n.1, p.419-28, 2009;
- _____. *Projeto de organizações integradas e flexíveis*. S. Paulo: Atlas, 1999.
- _____; FREITAS, S. L. T. U.; MISSAWA, V. A influência da Petrobras no desenvolvimento tecnológico: o caso das empresas de serviços de engenharia. In: DE NEGRI, J.A. (org.) *Poder de compra da Petrobras: impacto econômico nos seus fornecedores*. V.2. Brasília: Ipea, Capítulo 16, p.441-494, 2011.
- SALERNO, M.S.; GOMES, L.A.V. *Gestão da inovação (mais) radical*. Rio: Elsevier, 2018.
- _____; GOMES, L.A.V.; BAGNO, R.B.; SILVA, D.O.; FREITAS, S.L. T.U. Innovation processes: which one for which project? *Technovation*, v.35, p.59-70, 2015.
- _____; MIRANDA, Z.; KAMISAKI, Y.; MALUTA, G. Alavancando pesquisa, desenvolvimento e inovação no setor de autopeças: análise e propostas a partir de survey e estudo qualitativo focado. *Produção*, v.20, n.4, p. 565-575, 2010.
- SANDERSON, J. Risk, uncertainty and governance in megaprojects: a critical discussion of alternative explanations. *International Journal of Project Management*, v.30, n.4, p. 432-443, 2012.
- SARASVATHY, S. D. Causation and effectuation: towards a theoretical shift from economic inevitability to entrepreneurial contingency. *Academy of Management Review*, v.26, n.2, p. 243-263, 2001.
- SAUSER, B. J.; REILLY, R. R.; SHENHAR, A. J. Why projects fail? How contingency theory can provide new insights: a comparative analysis of NASA's Mars Climate Orbiter Loss. *Int. J. of Project Management*, v.27, n.7, p. 665-679, 2009.
- SCHRADER, S.; RIGGS, S. W.; SMITH, R. P. Choice over uncertainty and ambiguity in technical problem solving. *J. of Eng. and Tech. Management*, v.10, p.73-99, 1993.
- SHENHAR, A. J. One size does not fit all: exploring classical contingency domains. *Management Science*, v.47, n.3, p. 394-414, 2001.
- _____; DVIR, D. *Reinventing project management: the diamond approach to successful growth and innovation*. Boston: Harvard Business School Press, 2007.
- SIMON, H. A. *Comportamento administrativo: estudo de processos decisórios nas organizações administrativas*. Rio de Janeiro: FGV, 1965.
- SOMMER, S. C.; LOCH, C. H. Seleccionism and learning in projects with complexity and unforeseeable uncertainty. *Management Science*, v.50, n.10, p.1334-47, 2004.
- TEECE, D.J. Explicating dynamic capabilities: the nature and microfoundations of (sustainable)enterprise performance. *Strategic Man. Journal*, v.28, p.1319-50, 2007.
- THIOLLENT, M. *Crítica metodológica, investigação social e enquete operária*. São Paulo: Polis, 1980.
- THOMPSON, J. D. *Organizations in action*. New York: McGraw Hill, 1967.
- VAN DE VEN, A.; HUBER, G. Longitudinal field research methods for studying processes of organizational change. *Organization Science*, v.1, p. 213-219, 1990.
- _____; POOLE, M.S. Methods for studying innovation development in the Minnesota Innovation Research Program. *Organization Science*, v.1, n.3, p.313-35, 1990.
- VOHORA, A.; WRIGHT, M.; LOCKETT, A. Critical junctures in the development of university high-tech spinout companies. *Research Policy*, v.33, n.1, p.147-75, 2004.
- VOSS, C.; TSIKRIKTSIS, N.; FROHLICH, M. Case research in operations management. *International Journal of Operations and Production Management*, v.22, n.2, p. 195-219, 2002.
- WARD, S.; CHAPMAN, C. Transforming project risk management into project uncertainty management. *Int. J. of Project Management*, v.21, n.2, p. 97-105, 2003.
- WOODWARD, J. *Industrial organization: theory and practice*. Oxford: OUP, 1965.
- YIN, R.K. *Case study research*. 5ed. Thousand Oaks (CA): Sage, 2014.