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Valuation of innovation projects with high uncertainty: Reasons behind the search for real options

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ABSTRACT

Real Options (RO) has been indicated to valuate projects with high uncertainty. However, literature points to challenges and asks for an organizational understanding of its use. So: Why do managers search for the RO approach to valuate radical innovation projects? Based on five in-depth case studies, we discuss hidden organizational and managerial issues related to the search for RO to valuate radical innovation. We argue that managers search for RO to cope with the "paradox of organizational fit", and later, to deal with the "newness prison", employing RO Structuring and RO Integration to allow exposure to radical innovation.

1. Introduction

A critical challenge for firms is to define a proper approach to evaluate radical innovation (RI) projects, characterized by high uncertainty. Decades of scholarship have shown that inadequate managerial approaches are able to extinguish radical initiatives (e.g., Christensen et al., 2008), leading to incrementalism in the portfolios (Cooper, 2013). Indeed, the financial *valuation* of RI is a complex task (Paulson et al., 2007). While incremental innovation relies on historical data related to well-known technologies and the market, radical innovation deals with uncertainties from different sources (Rice et al., 2008), including "unknowns-unknowns" (Meyer et al., 2002) and a lack of, or poor, data.

A number of studies have indicated that traditional financial tools, such as Net Present Value (NPV), Return of Investments (ROI) and the like, are not suitable to valuate RI projects, since they are not capable of dealing with the lack of past data, uncertainty, the investment reversibility in innovation. Additionally, they do not take into account managerial flexibility – the possibility of changing the project path during its execution (Huchzermeier and Loch, 2001; Santiago and Vakili, 2005; O'Connor et al., 2008; Kester et al., 2009; Goffin and Mitchell, 2010; Wang et al., 2015). Some authors consider Real Options (RO) as a more suitable approach to the context of RI (e.g., Huchzermeier and Loch, 2001; Santiago and Vakili, 2005). RO would support the technical valuation of radical

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projects, making them easier to justify and manage and would also quantify managerial flexibility, allowing these projects to appear financially more attractive (Perlitz et al., 1999; McGrath and Nerkar, 2004).

Even though there has been a technical development of RO methods, there is still an ongoing concern expressed in innovation literature (Huchzermeier and Loch, 2001; Santiago and Bifano, 2005; Wang et al., 2015): that firms struggle to implement RO effectively (Reuer and Tong, 2007). Studies have found important challenges and barriers to RO: its intrinsic mathematical complexity, the non-intuitive results it produces, the lack of awareness of its mechanisms by most of the decision-makers, and the difficulties that still exist in modeling really disruptive projects, containing "unknowns-unknowns" (e.g., Fredberg, 2007). Nevertheless, some scholars have indicated that firms continue to search for RO in order to valuate innovation projects (Wang et al., 2015). This leads us to the following research question: *Why do managers search for RO to valuate radical innovation projects?*

Indeed, there is a lack of empirical and theoretical development regarding the organizational – broadly speaking – side of the search for the RO approach (Barnett, 2005; Coff and Laverty, 2007; Tong and Reuer, 2007; Barnett, 2008). To shed light on this search is critical to theory and practice. Uncovering these organizational aspects might illuminate the hidden reasons why managers search for RO to valuate RI and, therefore, increase the understanding of the dilemmas and bottlenecks of RI management. Such awareness is fundamental for a more comprehensive development of a theory of RI management. The investigation of the hidden issues behind the search for RO in the context of radical innovation advances the academic knowledge in several ways. For instance, it adds to the understanding of the organizational aspects influencing the implementation and use of the RO valuation approach. Additionally, it frames the role of legitimacy in introducing "management innovations" (Birkinshaw et al., 2008), since RO is an attempt to manage RI within a firm's current legitimated organizational and managerial system. This key point is often neglected by RO literature, which tends to be focused on the technical, and less on the legitimation, side of managers' decisions. Moreover, it extends the scholarly elaboration on the challenges of performing RI continuously, considering the difficulties in managing radical and incremental projects in the same portfolio (Chao and Kavadias, 2008; O'Connor et al., 2008; Kelley et al., 2011).

To address these questions, we draw on the literature concerned with the valuation of projects with high uncertainty and on the literature of RI management, notably those dedicated to organizational aspects. Based on this body of knowledge, we build a conceptual framework, which compiles the main aspects related to RO in innovation management and carry out five rich, longitudinal, inductive, in-depth case studies in firms searching for the RO approach to valuate RI projects.

Based on the interaction between the conceptual framework and the empirical data, we contribute to theory in several ways. First, we identified that managers search for RO to deal with the "paradox of organizational fit". We found that this paradox emerges when: i. Firms start to perform radical innovations, ii. Managers are assigned to fulfill a portfolio of radical innovations, iii. Managers consider that their firm's board would consider decisions more legitimate if current systems are used, iii. But, as current systems are not adequate to RI, managers lose legitimacy when facing failures and setbacks common to RI. Second, after deciding to use RO, managers face another challenge we call the "newness prison": when they decide to perform something new by using a new way, they also lose legitimacy. Third, we found that managers search for ways to structure the decisions required for a project, using RO trees – we term this RO Structuring. Fourth, managers look for a communication and a mindset bridge across different levels: project, portfolio, and strategy – we term this RO Integration. Based on these findings, we developed illustrative propositions and a research agenda.

Our work has the following structure: Section 2 focuses on the theoretical background to support the field study; Section 3 describes the methodological design of the research; Section 4 presents the results and the evidences from the case studies; Section 5 discusses the main findings, their relationships with the literature and with the research question; Section 6 provides the conclusion and final considerations.

2. Theoretical background

We draw on the relevant literature to support the empirical study. First, we discuss the important literature to interface innovation management and valuation, focusing on organizational and managerial aspects. Second, we discuss RO and its application in innovation management. Finally, we present a conceptual framework to guide our fieldwork.

2.1. Project valuation and the innovation management system

The development of a radically new product, process or technology innovation is surrounded by uncertainties from different sources – technical, organizational, market, and resources (Rice et al., 2008), carrying "unknowns-unknowns" that increase project complexity and ambiguity (De Meyer et al., 2002; Pich et al., 2002; Sommer et al., 2009). This creates challenges for project valuation, and it may become inviable to use the traditional financial tools (NPV, ROI, IRR) as the data is unreliable (Schneider et al., 2007). However, project valuation is a critical task for innovation portfolio management (Cooper et al., 1999), because it relates to the judgment of the viability of a single project – the "valuation problem" (Goffin and Mitchell, 2010), and to the relative viability, where resources need to be divided between projects in the portfolio.

The incapacity of traditional financial methods to work in cases of data unpredictability is one of the reasons pointed to by the literature for making them non-adherent for innovation projects (McGrath and Nerkar, 2004). It is not possible to have market data for a radically new product that creates a new market. When the product is completely new, that is, when it does not substitute an existing one, it is virtually impossible to have an accurate market evaluation (O'Connor et al., 2008). When the project relies on a radically new technology, or on a new integration of different technologies, it is very difficult to predict future production costs (Salerno et al., 2015). Therefore, the use of financial metrics, as the main metrics in managing RI portfolios has received criticism

from several scholars. Cooper et al. (1999); Paulson et al., (2007); Terwiesch and Ulrich (2008); Kester et al., (2009); Goffin and Mitchell (2010); Cooper (2013); Gutiérrez and Magnusson (2014), for instance, all discuss the difficulties in dealing with financial aspects of a project in the RI environment.

Contradictorily, although several non-financial tools exist, aiming to aid the portfolio management of projects with high uncertainty, such as scoring approaches, bubble diagrams and others (Cooper et al., 1997, 1999; Mikkola, 2001; Paulson et al., 2007), the use of financial tools remains more attractive and companies still search for them. So, there is a growing concern among academics and managers for the need of more efficient tools to valuate projects. In this context, RO has emerged as a potential approach to performing more appropriate valuation of projects which have high uncertainty (McGrath, 1997; Huchzermeier and Loch, 2001; Santiago and Bifano, 2005; Santiago and Vakili, 2005; Wang et al., 2015), enabling their quantification and comparison with other projects in the company.

There is the concern in the literature to comprehend how RI projects are protected during the process of comparison, prioritization and resource allocation, especially when competing against incremental projects (Cooper et al., 1999; Chao and Kavadias, 2008; Terwiesch and Ulrich, 2008), with data, again, reinforcing that traditional financial tools increase portfolio incrementalism (Cooper, 2013). Different portfolio decision-making genres require different management practices, linked to different levels of innovativeness (Kester et al., 2009). First, from a broader perspective, researches have investigated organizational aspects related to RI project decisions, such as: the managerial role in RI management (Kelley et al., 2011); the human aspects in managing RI (O'Connor et al., 2018); the need of particular organizational designs for RI (O'Connor, 2008, 2012), based, for instance, on the principles of balancing exploration and exploitation activities (March, 1991; O'Reilly and Tushman, 2004), considering the role of organizational ambidexterity (Raisch and Birkinshaw, 2008), and investigating the managerial capabilities required for RI (O'Connor, 2008; O'Connor et al., 2008).

Second, one important facet of the relationship between innovation project valuation and the general management system is the legitimacy of the decisions and of the methods themselves. Legitimacy has been discussed in general management literature for a long time (Zucker, 1977; Suddaby and Greenwood, 2005), and also in innovation management literature. Bunduchi (2017), for instance, explores legitimacy-seeking behavior in product innovation, going beyond the rational perspective and highlighting the influence of the organizational context in shaping legitimation mechanisms. Gutiérrez and Magnusson (2014), additionally, indicate that rational perspectives (such as financial frameworks) are more acceptable, pointing out that innovation managers adopt different legitimacy mechanisms to bypass established decision-making processes and validate non-rational decisions.

Third, while research on management innovation investigates the creation and implementation of novel management approaches or tools, it is also concerned with the legitimation of decisions resulting from practices not normally internalized by firms (Birkinshaw et al., 2008). Mol and Birkinshaw (2009), for example, look at the sources of management innovations, contributing to the understanding of why firms search for other management approaches. Their work indicates that organizational context and interaction between internal and external sources are key issues in understanding the adoption of novel management techniques, such as valuation approaches.

2.2. The Real Options approach and its implementation

The RO approach consists of a set of alternative methods to valuate a project, based on the idea that managerial flexibility can be quantified and this increases the global value of a project (Dixit and Pindyck, 1994). The approach, derived from the financial options theory (Black and Scholes, 1973; Cox et al., 1979), was adapted to deal with projects (Myers, 1977; Trigeorgis, 1996; Luenberger, 1998) having high uncertainty, where traditional financial methods are ineffective. The approach is based on the presumption that the manager has the option, not the obligation, to take a managerial action in the future, depending on the contingencies and new information. Wang and Yang (2012) call it managerial flexibility.

RI projects are characterized by the low level of predictability; being prone to influence from several sources of uncertainty (Rice et al., 2008) and presenting different decision paths in their course – e.g., abandon, license, improve, or continue. These characteristics stimulated the adaptation of RO to valuate innovation projects (McGrath, 1997; Perlitz et al., 1999; Huchzermeier and Loch, 2001; McGrath et al., 2004; Lo Nigro et al., 2014; van Zee and Spinler, 2014; Wang et al., 2015).

The authors referred to above present several arguments to justify RO in innovative environments. In general, traditional financial methods penalize uncertainty through rates "adjusted to risk", which diminishes NPV or IRR. RO should increase project value, adding the value of managerial flexibility (Huchzermeier and Loch, 2001; Krychowski and Quélin, 2010).

The analysis of RO implementation, considering the managerial, organizational and strategic aspects, is one of the research frontiers of the topic (Bowman and Moskowitz, 2001; Adner and Levinthal, 2004; Barnett, 2005; Tong and Reuer, 2007; Barnett, 2008; Klingebiel and Adner, 2015). Barnett (2005, p. 69) argues that "organizational and environmental factors have direct effects on the gap between option potential and realization." For Tong and Reuer (2007, p. 16), "Real Options theory does not speak directly to managerial and organizational capabilities required for implementation, more research in the area can help to specify the theory's boundaries and enhance its managerial relevance." Krychowski and Quélin (2010, p. 74) consider that there is space to study the conditions for a successful implementation of RO, saying that "future research in RO will have to shift from a 'financial' to a 'strategic' perspective and pay much greater attention to the behavioral and organizational constraints in the use of RO analysis."

Scholars indicate how interrelated the search for RO is with other organizational aspects. For instance, McGrath et al. (2004) recognize RO as heuristic for strategic investments, the Real Options Reasoning (ROR). Tong and Reuer (2007) and Trigeorgis and Reuer (2017) highlight RO as part of strategic management, being an important tool for the operationalization of strategy.

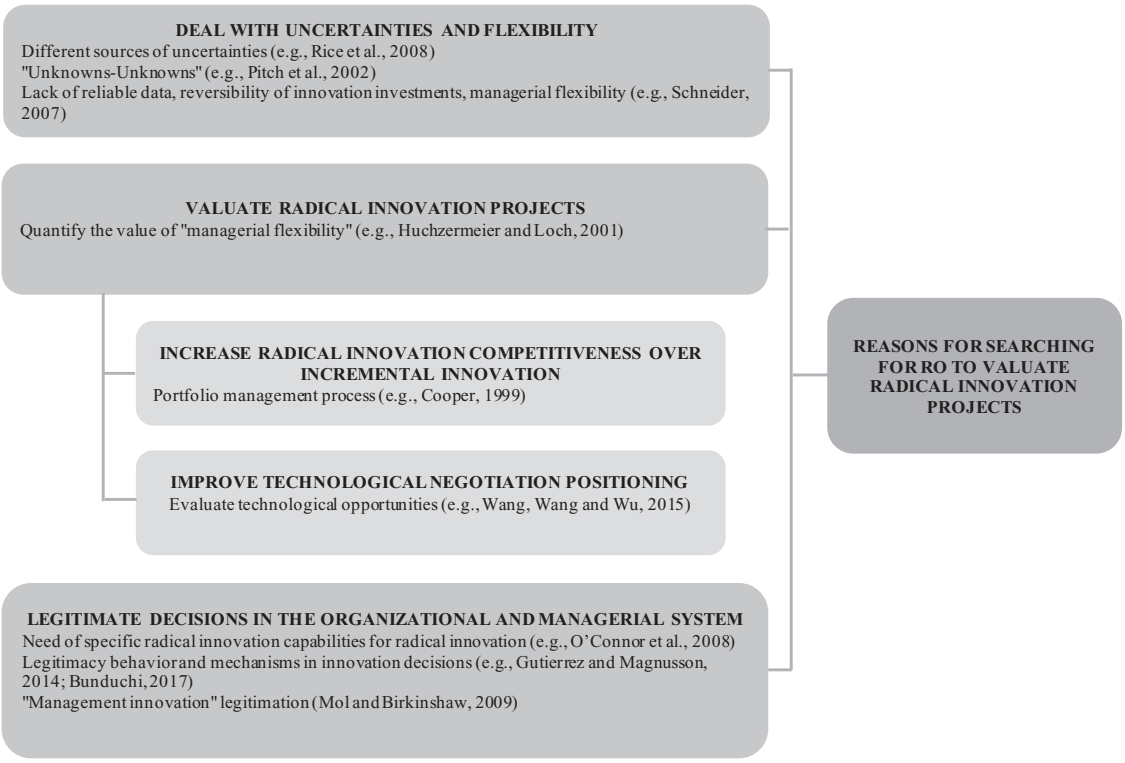

Fig. 1. Conceptual framework.

2.3. Conceptual framework

Based on the theoretical background, we developed a conceptual framework (Fig. 1), summarizing the reasons driving the search for RO to support our data collection and analysis.

3. Research method

At this stage of our research, we proceed to multiple case studies. Our aim was to investigate in depth the reasons why firms or, more specifically, some managers, are looking for new ways to valuate RI projects.

Case studies are the traditional methodology for research questions such as the present one. The nature of this research, based on the understanding of a phenomenon not completely understood in its environment, and characterized by an inductive and exploratory work dealing with unknown variables, indicates the use of case studies to be appropriate (Eisenhardt, 1989; Yin, 1994; Voss et al., 2002). In each company, we analyzed one or more projects. Often, there were different portfolios (R&D projects, process or product improvements, etc.) and projects were evaluated differently in the same portfolio.

We proceeded to longitudinal studies, following projects during an extended period of time. Radical projects usually take a long time to be developed (O'Connor et al., 2008; Govindajaran and Trimble, 2013). Our conceptual framework guided the development of the script employed in the interviews, addressing the following topics: i. Innovation management system; ii. Valuation processes; iii. Reasons for searching for Real Options; iv. Challenges associated with the use of Real Options. By following projects, we aimed to map the decision-making process, to understand resource disputes and legitimation issues. We researched projects in five companies (Table 1). Cases 1, 4 and 5 have engaged in RO valuation. Cases 2 and 3 have not effectively engaged in RO, but searched for its use, to act as a counterpart and provide alternative insights of the valuation issue.

The key aspect of our data analysis was to identify the reasons behind the search for RO to valuate RI projects. For this reason, initially, the apparent demands of searching for RO were framed (in line with our conceptual framework) and, then after this, the hidden demands. First, our research group came to a common understanding on the reasons for managers searching for RO. We began by framing in each case the process of searching for RO as a story, building tables and timelines, representing when, why, and how the firms searched for RO. We also added to the stories, by giving examples of projects in which managers tried to employ RO. Comparing the cases, four patterns related to the hidden reasons for the search emerged: the "paradox of organizational fit", the "newness prison", RO Structuring, and RO Integration. These patterns might be understood as factors or aspects that explain the reasons why firms search for RO. While the first two factors refer to the introduction of a new practice (using RO for valuation), the other two add to the literature of RO, complementing the research streams of RO valuation and RO Reasoning.

The first factor, the "paradox of organizational fit", refers to situations in which managers decided to perform RI projects by using

Table 1
Research details: cases and instruments.

Case	Business	Period of research	Research Instruments / Protocol
1. Green chemical	Company in the race for green chemicals. Central R&D and management of radical new projects to be further transferred to production facilities.	Longitudinal (2008–2017), intensified in 2013–14, and in 2017.	Interviews and discussion with the CEO, CTO, CIO (Innovation VP), Bus VPs unit, innovation managers, PMO, technical staff on finance, investments, innovation, several times. In-company course on project valuation and uncertainty management. Immersion in projects.
2. Traditional petrochemical	Basic products from crude oil. Organized in business units (BUs). Each BU manager has large power over "its" business.	Longitudinal (2010–2015), intensified in 2014.	Interviews and discussion with VPs, product & process innovation managers, innovation staff, R &D professionals, PMO. Immersion in the company.
3. Specialty chemical	Petrochemical (specialties) fighting against the commoditization of its products.	Longitudinal (2013–2015).	Interviews and discussion with CEO, main shareholder, R&D director, R&D managers, innovation manager, PMO.
4. R&D company	R&D company, developing biotech processes for new generation of renewable ethanol production.	Longitudinal (2014–2015).	Interviews with owners (managers), investor (venture fund). Detailed analysis of one project, aiding the company to introduce RO to its valuation.
5. Veterinary products	Veterinary pharma, looking for new process (biotech) for a given substance.	Longitudinal (2013).	Interviews and discussion with innovation manager and project management staff. Immersion in a key innovation project.

their firm's established approaches. We initially identified this situation in Cases 1 and 2. Our research discusses the main characteristics associated with this situation and, based on empirical evidences, we pointed out the causes, actions and consequences. We then coded this situation as the "paradox of organizational fit": when managers search for legitimacy by performing something new (RI projects) using their firm's established processes. The second factor refers to the challenge of introducing a new practice to do something new. We term this factor as the "newness prison", owing to the difficulties associated with overcoming this challenge. RO Structuring aims to provide a way of planning a radical innovation. RO Integration aims to provide a manner for communicating a radical innovation in terms of logic, content, sequence, and progress. In this way, RO seeks to provide a new language and tool for modeling and communicating RI projects to the rest of the organization. Additionally, what we call RO Integration consists of a common set of heuristics related to what RO is, how it works, and why it should be used. Once we identified these factors, we compared the situations in which these factors emerged in the cases. Based on these elements, we proposed an exploratory approach for explaining why firms search for RO to evaluate RI projects.

4. Evidences from the case studies

Guided by our conceptual framework, we investigated in depth in the cases: 1) The apparent reasons why firms are searching for RO: the problems enunciated by the company; 2) The hidden reasons why they are conducting this search, highlighting the issues behind the official discourse. As a contextualization, we first give a brief description of the cases.

4.1. Case 1: green chemical

4.1.1. Case description

Case 1. refers to a chemical multinational with operations mostly in the Americas, but also in Europe. It is a market leader in some technological areas on renewable chemicals. The company has set renewable chemicals (that is, to produce chemical commodities based on renewable sources) at the center of its corporate strategy, but it has a history of traditional chemical production that is still the largest part of the business.

In 2007, this company decided to implement an ambidextrous organizational strategy (the Corporate Innovation VP), which consisted of creating a special separated organizational unit devoted to perform RI projects. The expectation associated with this unit was to build the capabilities needed to operationalize the corporate strategy: to become the world leader in the emergent green chemicals market. The mission of this unit was to explore new ideas internally and externally; to evaluate, select and develop the best ones until the proof of the concept; to overcome the main market and technological uncertainties; to manage external partners, such as universities and startups; and to help to introduce a technology innovation strategy in incumbent businesses.

4.1.2. Apparent reasons: the problem as enunciated by the company

At the beginning, one of the most critical challenges declared by managers was how to evaluate and select RI projects, and, consequently, to fulfill a portfolio of RI projects. The managers had a solid expertise on project valuation, based on traditional financial techniques (related to incremental innovation). Initially, they decided to use these traditional techniques to valuate and select RI. They considered that the use of these approaches would allow the board to easily analyze and evaluate the RI portfolio and each project's performance. However, the application of such techniques implied in the rejection of projects, showing the traditional

techniques to be inappropriate. In addition, because these traditional approaches did not predict accurately how radical innovation projects would progress, the failures and errors related to experimentation were attributed to managers' (in)abilities, rather than to events inherent to experimentation and learning. As a consequence, managers started to lose legitimacy. Then, the managers decided to search for more adequate approaches to evaluate RI projects. Looking at the specialized literature, consultancies, and based on previous experiences of strategic partners, the managers identified that RO could be used to account for the value of RI projects. As the managers had very few valid experiences with RO, the company hired a consultancy to employ RO in two RI pilot projects. The service was to involve all employees and managers of the unit, in order to transfer knowledge to them and help build an organizational capability on valuation. They expected to make RI projects more competitive vis-à-vis incremental ones. This proved to be unsuccessful.

4.1.3. Hidden reasons: issues behind official discourse

At first, the consultants faced challenges in accessing data to perform the valuation of projects, and finding that the business team had a low familiarity with the RO approach. However, the most relevant barriers were related to the hidden agenda of the managers in this unit: they wished to use RO to legitimate decisions in the eyes of the directing board, in order to reinforce the unit during internal disputes for budget. From the early days, many other managers saw the new unit as "undisciplined", because it did not use the traditional valuation tools of the company. The unit was set up to be different; but, paradoxically, it faced a permanent challenge to gain legitimacy in the overall company. Disputing budgets for projects was challenging, particularly after the arrival of a new CEO. Corporate Innovation thought RO was a way to change its image and to improve chances in internal disputes; but, at the end of the day, managers faced more loss of legitimacy. The board had difficulties in understanding the rationale of RI projects (a distinct type of project) and of RO (a new way to perform valuation).

Although RO increased the problem of legitimacy, managers still employed it internally as way to structure projects. The ultimate ambition was that RO would help to set a proper mindset for RI projects at a strategic level (C-level), at the portfolio level, and at the project level.

4.2. Case 2: traditional petrochemical

4.2.1. Case description

The company grew by incorporations in several countries. Process technology was historically licensed from key actors. The growth of the company closed doors with technology suppliers, since they had the perception they were creating a competitor. Therefore, the company set an R&D center to develop industrial processes as well as new specifications and uses for its products.

At a meeting in 2010, there was a discussion about the general structure and managerial system, the bonuses for managers, and for all employees. The company contracted a large multinational consultancy to implant the traditional funnel/stage-gates process to manage innovation. An employee can register an idea in the system, which is sent to an expert for a first analysis, and then the idea can go through the traditional flow of activities and gates. The system was designed for incremental innovations. To cope with the prerequisites of a common horizon to perform NPV analysis (Fleischer, 1969), the consultancy established standard horizons of three or five years. Moreover, some projects to develop catalysts and process technology had a horizon of more than ten years. Summing up, there was a problem with the innovation process in the company; it under evaluated RI projects, leading the innovation manager, already familiar with RO, to try to implement it.

4.2.2. Apparent reasons: the problem as enunciated by the company

From 2010–2011, we followed projects on new specifications and new applications for current products. These incremental projects ran well in the system. However, in late 2013–early 2014, in discussion with an innovation manager, we were told of a problem with the project valuation system. The issue was raised as how to define the horizon of projects to perform NPV analysis. Some project leaders argued against valuations made by commercial staff, saying they were conservative: having a short horizon.

In the company, a manager was assigned a project if it continued after the first gate. This manager then built a team with commercial and marketing staff, which set the parameters for the first valuation: prices, volumes, rates adjusted to risk. This penalized RI projects, which have longer time horizons. Formally, this initial valuation could be altered, but, in practice, this was not the case. That is, such valuations made sense only for incremental projects with low uncertainty. Then, the project was judged by a committee (at the gate).

The main corporate innovation manager searched for how to define a project's horizon. Project managers were raising concerns on the limitation to the predefined horizons, which prejudiced some projects, since these projects had less time to capture incomes. This was because expenditures were higher before launching a product and income might occur after the predefined horizon.

In a joint discussion with three project leaders and the innovation manager, we perceived a bypass on the horizon rule. Some projects concerning patents (intellectual property) or process development were considered to have a ten-year horizon. For triangulation purposes, we asked the innovation manager to inform us of the actual horizons for the projects. By listing more than 200 innovation projects of all kinds, we perceived that horizons varied from two to 12 years, in a kind of normal curve. Summing up, the company managed informally to cope with the restriction of three to five to ten years. So, what was the reason for the concern?

4.2.3. Hidden reasons: issues behind official discourse

The inconsistency between the discourse and the data regarding horizons suggested to us that the argument about horizons was the surface of an iceberg. Horizons were a symptom, not the root of the problem. After some months of discussions, interviews, and

the analysis of the actual horizons (which came as a surprise to the innovation management team), we realized that the real problem was the low adherence to the innovation process formally installed in the company with more uncertain projects, and the whole mindset and managerial system. The company was organized in highly autonomous Business Units (BUs). BU managers decided resource allocation – the share for R&D, NPD, and quality projects, etc. It is an appealing policy, allowing fast decision-making, close to customers, and suitable for tracking incremental projects to satisfy current customers and to increase short-term results, despite of not suitable to radical innovation.

In further triangulation rounds, during an intranet meeting with project leaders located in different facilities, we perceived that project managers were evaluated by the sum of the NPV adjusted to the risk of the projects under their umbrella. This procedure was clearly tracking for incremental low-risk, short-term projects to maximize NPV – and managers' bonuses.

The search for RO was the search to solve the "paradox of organizational fit" – that is, the attempt to perform RI inside the current managerial system characterized for incrementalism. RO was seen as a potential method to better evaluate more innovative projects, raising their value and the bonuses of their managers. If it worked, it was a clever way to gain legitimacy for RI projects. At the same time, the RO search was an attempt to contour the "newness prison", as we will show in the discussion section.

4.3. Case 3: specialty chemicals

4.3.1. Case description

Company 3 produces specialty chemicals like agrichemicals, surfactants, lubricants, specialties for home and personal care, performance products for textiles and the food industry. This company has become multinational with production units all over the Americas (North and South) and offices in China and Europe. Decades ago, it started operations producing basic petrochemicals, but then realized that its core product was in a process of commoditization, since other companies were entering the market, compressing prices. The fear of commoditization directed the company to the new business of specialty chemicals from the basic core product it used to produce. However, although the company developed special products for large customers (e.g., surfactants adapted for a special use), other companies around the world did the same. Worse still, in the meanwhile, new technologies were being developed, gaining market share and depressing the company's margins. To cope with this strategic risk, the company decided to invest in technological development. As a result, the development portfolio was changed by the incorporation of more radical projects.

4.3.2. Apparent reasons: the problem as enunciated by the company

The company identified a portfolio management problem. Projects were evaluated and compared in the portfolio via NPV. When the R &D center started some more radical projects, managers tried initially to employ NPV. Similar to the previous cases, managers were unable to evaluate them applying traditional financial tools. That is, the rise in uncertainty led to a lack of data for the parameters necessary to run these kinds of tools, such as the temporal horizon (the length of the development), expenditures (comprising R&D, product development, production, and commercialization phases), and income. However, these projects were being compared in the same portfolio as simple product adaptations. As NPV was not applied to the radical projects, the RI projects' NPVs were assumed to be zero. We saw a slide projection, a graph automatically drawn from a spreadsheet, comparing the NPV of the different R&D projects, and the radical projects (the strategic ones) were shown as "dead" – a red line in zero. This was a schizophrenic situation: projects with higher strategic importance were being shown as less valuable than simpler ones. R&D managers had always to explain that, although in zero, these projects were the most important and should attract a greater budget, in terms of money, human-hours, lab-hours, etc. Nevertheless, a red line in zero was a strong sign and contributed to the loss of legitimacy in front of the rest of the company. To contour the situation, the R&D director was looking for new tools for portfolio management. New approaches, such as RO, could better represent reality and would permit the evaluation all kinds of projects in the same way. Here, also, managers were afraid that, as RO was new to the company, the board would have difficulties in understanding how RI projects were evaluated.

4.3.3. Hidden reasons: issues behind official discourse

We perceived a different agenda after in-depth discussions with the R&D director and managers, the PMO, an ex-CEO at the time presiding over the board of directors, and executives of a governmental innovation agency that was funding several projects. The new innovation strategy was not well understood in the company. Although formally supported by the board of directors, innovation was not a priority in budget elaboration and in capital allocation. The valuation problem reflected the contradictions of the move towards a stronger R&D. The innovation management system was still designed for the older strategy (related to very incremental innovation), and it did not support the requirements for performing RI. Managers lacked tools for structuring RI projects and communicating them to the board of the company. Moreover, R&D managers indicated that the firm lacked a proper culture related to RI and was more tolerant to trial-and-error experimentation. Owing to the strong incremental innovation background, managers perceived that errors and failures related to experimentation would lead them to lose legitimacy, and some managers left the company.

4.4. Case 4: biotech startup

4.4.1. Case description

Case 4. is a small startup company, which focuses its activities on the R&D of new processes and products based on renewable materials. The startup had four main acting lines: 1) The development of new third-generation bioethanol production processes; 2) The development of herbal drugs and cosmetics; 3) Technical analyses and reports about heavy metals contamination; 4) Biochemical analysis in general. In this study, we followed specially a project that was aimed at the development of a new process to produce

third-generation bioethanol. This generation is produced using the sugar cane substratum generated after the fermentation is realized during the production of first-generation ethanol. The substratum is placed in a bioreactor with microorganisms and a second batch of ethanol is produced without the need of further operations. This technology was patented and the intention of the owners was to develop the new technology and license it to small refineries located in some specific communities, a kind of social approach.

The need of financial resources for this project was high. Equally high are its technical and market uncertainties. A venture capital fund, focused on social projects and initiatives, supported the company considering its social-driven strategy. To acquire this fund, the entrepreneurs employed traditional valuation techniques, such as NPV; the entrepreneurs considered the employment of such approaches would improve their legitimacy and the competitiveness of the project.

The startup contracted a consultancy aiming at clearing and organizing its business model. After some months of interaction, the owners realized that the initial idea of licensing the use of the production process to small refineries was not the best strategy to diffuse the technology. The lack of control over who would use it; the complexity of operating a process with this level of sophistication, and the possibility of a refinery copying the process, decreasing the patent value, were some of the factors that influenced the decision to change the strategy. The entrepreneurs decided to find a way to license the patent rights to a large company able to pay a great amount of money, and so, use these financial resources to finance the development of other projects.

4.4.2. Apparent reasons: the problem as enunciated by the company

The entrepreneurs identified the need to quantify the value of the technology, the value of the patent at that time, and to have a strong position in the bargaining process with potential clients. The idea was to visualize the “real” value for licensing. As the innovation had a number of uncertainties, the entrepreneurs and the consultants decided to conduct a valuation using RO. The owners elaborated five scenarios, based on different possible technological performance parameters and eight different sizes of a future industrial plants, varying the quantity of third-generation ethanol produced in each one. The scenarios built enabled a cash-flow projection and the simulation of the future financial reality. Huchzermeier and Loch’s (2001) RO model was applied. At the end, the entrepreneurs had a value on which to base possible future negotiations with companies interested in buying the technology, or to know how much should be charged to license the technology.

4.4.3. Hidden reasons: issues behind official discourse

The claim of defining a value for the technology developed, or for the royalties to charge future users, was just the apparent driver for the application of RO. The characteristics of the method in covering managerial flexibility and forcing the elaboration of option trees were attractive from the entrepreneurs’ point of view, once they were searching to minimize uncertainties and define the best strategy and business model. The biotech startup was not confident enough in how it should deal with its strategy. It was not clear if the business model defined would be appropriate in the circumstances. The “gains” generated by the use of the RO approach in developing scenarios and designing options helped the company to clarify the configuration of the business and to rethink the choices made in the past. We monitored the discussions to set RO decision trees. It became evident that the technology had not been tested for its technical viability on a larger scale; there was a scaling-up technical uncertainty.

In the case, RO was initially thought of as a tool to increase the market value of the technology. Initially, the technology uncertainty was not considered, and it only became clear when the entrepreneurs tried to set the option tree to support the RO valuation. This case shows a different side to RO: the RO approach helped to identify uncertainties. There may be easier methods to do so (Rice et al., 2008), but RO was the approach used by this company.

4.5. Case 5: veterinary products

This case is a large multinational company specializing in developing veterinary products. The manager had a budget for prospecting, pre-developing, and investing in some potential technologies. Based on the prospects, the company decided to develop a new generation of a particular veterinary product, by using a genetic manipulation in goats, in order to obtain a specific protein. Because of this goal, the company decided to build a partnership with a startup, which had two patents on intermediary products that were needed to produce the final veterinary product.

4.5.1. Apparent reasons: the problem as enunciated by the company

In this case, the company received support from researchers and students from the University of São Paulo (USP) to employ RO for valuating the project. According to the project manager, this support started by helping with the identification of the critical uncertainties of the project, using the learning plan proposed by Rice et al. (2008). One of the critical uncertainties identified was the contract in negotiation with the startup, which could potentially deliver a useless non-active substance. Then, the USP team proposed the contract should be changed, making it clear that payment would be made in line with the quantity of the active substance. In addition to the discussion on uncertainties, RO was used with three aims: i. Valuating the technology; ii. Valuating different technological options for obtaining the product; and iii. Defining the parameters for the best model of negotiation with the startup, which involved the large company playing the role of venture capitalist investing in the startup.

4.5.2. Hidden reasons: issues behind official discourse

Although the manager had a strong technical background, her expertise in management and valuation of technology projects were related to incremental innovation, and not to the radical ones. In other projects, the manager tried to employ traditional approaches

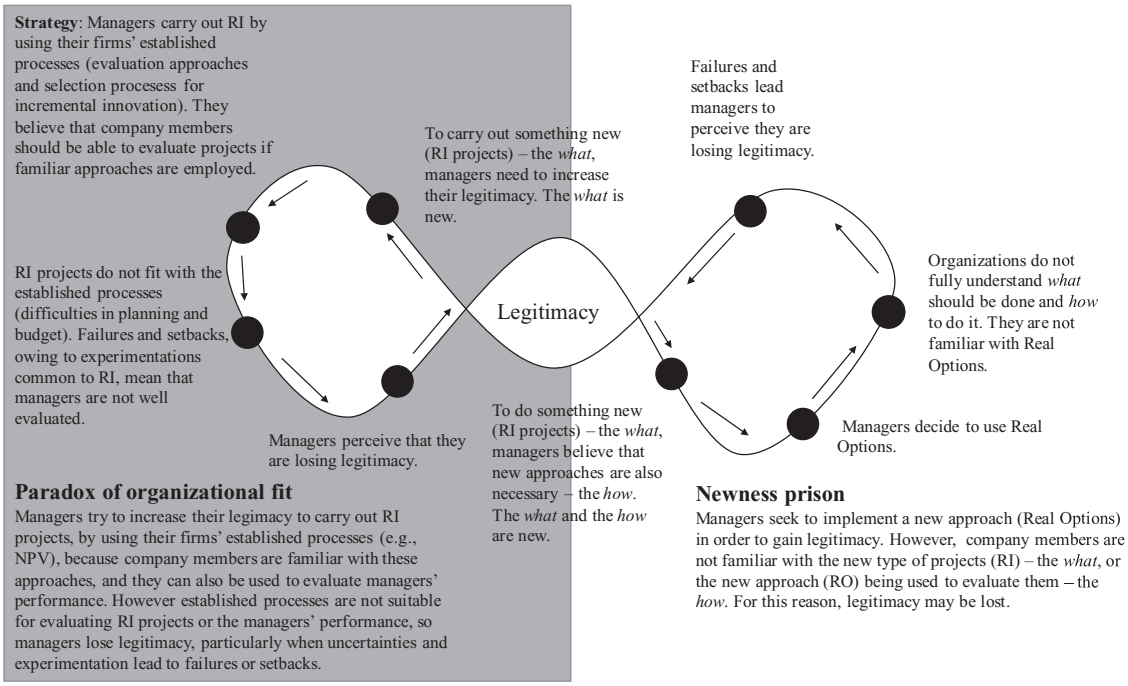

Fig. 2. The "paradox of organizational fit" and the "newness prison".

to evaluate RI, as it was the default procedure. Nevertheless, as this new project involved high levels of uncertainties, she decided to search for RO. The USP team helped to implement a systematic approach for coping with uncertainties. This approach led to identify critical uncertainties related to the value of the technology and the terms of negotiation with the startup. However, we perceived a hidden objective after some months of interaction with the company. The manager expected that, with RO, she could obtain more resources from the company in order to invest in other technological options associated with this project, since she was not convinced that the technology developed by the startup was the best choice. Here, RO was thought of as a way to gather data from the startup and, mainly, to increase her legitimacy, credibility and power, once she gained a more sophisticated approach for evaluating the technology. In turn, this could aid her to acquire more resources for projects. Additionally, as a sub-product, RO helped her to structure the project by framing the options, planning the activities and defining, step by step, the investment approach.

5. Discussion

Based on our cases, we identified several reasons behind the search for Real Options to valuate RI projects, complementing our conceptual framework. Initially, our cases reveal that managers search for RO mainly to cope with what we call the "paradox of organizational fit" and, later on, to deal with challenges related to what we call the "newness prison" (Fig. 2). In both situations, managers faced problems related to the search for legitimacy. The "paradox of organizational fit" emerges when managers try to increase their legitimacy, in order to carry out more RI projects, to acquire more resources for RI projects, or even to "save" a specific project, by using the firm's established processes. That is, managers valuate RI projects in a traditional way by using current, well-established and legitimated valuation techniques, whether by default or by a rational decision. The expectation here is to get legitimacy for RI projects and for their own work by doing valuation as usual. The paradox occurs when the process backfires on RI managers: valuation is either impossible because of lack of data, or by reasoning that does not fit with the company's practices. The paradox is that, by using traditional and legitimated techniques, RI projects and their managers become less legitimated in the company.

While the "paradox of organizational fit" refers to cases in which managers use old, well-known procedures to do something new (i.e., the RI projects), the "newness prison" refers to cases in which managers adopt new processes (the RO approach) to do new things (RI projects). Although this second situation may sound logical, it uncovers an important challenge: external actors (the rest of the organization not involved with RI) may neither fully understand these projects (as RI relies on new knowledges and "unknown-unknowns") nor how to perform these projects (consequently, they have difficulties in evaluating managers' performance). As a consequence, managers might face loss of legitimacy, particularly when RI projects have setbacks and failures owing to experimentation. Of course, the "newness prison" also creates new reasons for managers to search for RO: new ways of structuring projects (we term this RO Structuring), and new ways of communicating the project's importance and its progress (we term this RO Integration). In the end, RO can be a way to allow firms to expose themselves to projects that are more uncertain.

In the following sections, we discuss the constructs that emerged from the empirical research.

5.1. Dealing with the "paradox of organizational fit" when searching for an RO approach

Case 1. provides an illustrative example of the "paradox of organizational fit". Aiming to have more RI projects in the portfolio, managers initially tried to valuate and carry out the project using traditional approaches used for incremental innovation. The managers, either by default or by thinking it would be easier to persuade the executive board (C-level: CEO, VPs), utilized traditional approaches to valuate RI projects. The interviewees expected this strategy would be seen as more legitimate because company members were more familiar with such approaches, making it possible to establish comparisons and analysis among RI projects and the other incremental projects. However, as the RI projects did not follow a linear path, having setbacks and failures related to experimentation by trial and error, managers were unable to deliver their promises in terms of planning, budget, and scheduling, and could not properly explain the progress or the results of these projects. In addition, managers were not able to fulfill the portfolio of RI. Although the managers recognized that the established project valuation approaches were not appropriate to RI, to the rest of the organization such managers were seen as "undisciplined" and incapable of following the firm's processes. Therefore, through the lens of the traditional approaches, the rest of the organization regarded RI managers as having failed. Therefore, RI managers perceived the decrease of their legitimacy in the firm, receiving less attention and resources. RI projects were virtually abandoned.

We found similar patterns in Cases 2 and 3. Although Case 5 refers to a startup, we also found a similar manifestation of this paradox. The entrepreneurs used RO to raise the valuation of their technology and to gain better bargaining conditions with investors and for royalties; but investors rejected the approach, and the project and their supporters lost legitimacy.

Our cases reveal that the more managers tried to employ traditional approaches to valuate RI projects, the more exposed to loss of legitimacy they were, configuring the "paradox of organizational fit". We argue that this paradox emerges when managers try to valuate something new (RI) by using established managerial approaches/routines, instead of implementing new ones, believing that this strategy should increase their legitimacy. They adopt this strategy for several reasons. First, by default. Second, the introduction of a new process (a new way to do things) for performing a new activity might increase the complexity of evaluating the work (the valuation and performance of an RI project), and, consequently, the organizational resistance. Third, company members tend to compare the performance of these new activities (RI) with other ones by using the firm's established approaches. Because RI projects are substantially different from incremental ones, RI managers lose legitimacy.

In response to this loss (or lack) of legitimacy, managers search for new alternatives to evaluate and carry out RI projects, such as RO.

5.2. The "newness prison"

As mentioned, the managers of RI projects and the entrepreneurs faced the "paradox of organizational fit", losing legitimacy. As a response, they decided to introduce a new approach, i.e., RO, for valuating RI. For example, in Cases 1 and 2, managers strongly believed that RO was more suitable for the nature of RI projects, which are characterized by uncertainties. Of course, they were also aware that company members, including the board, would face difficulties in understanding how RO works. However, even though the introduction of RO was thought likely to create difficulties for the board in understanding the RI projects and their valuation, the managers considered this necessary in order to fulfill the portfolio to include RI projects and to improve their legitimacy. We found similar patterns in Cases 3, 4 and 5, where managers acknowledged that traditional methods did not successfully valuate RI projects and searched for new approaches, despite of organizational resistance, to increase their legitimacy and allow radical innovation projects to be agreed. Regarding the entrepreneurs in Case 4, they thought that RO would be more adherent to their innovation, capturing its uncertain nature, and provide a superior value. Also, to a lesser extent, in all cases, RO was expected to enable a better prediction of the development of the projects. This was expected to help cope with the uncertainties faced.

In contrast to what managers and entrepreneurs expected, the use of RO led them to lose more legitimacy. Cases 1 and 2 provide good illustrative examples of why this happens. In Case 1, the department responsible for the valuation of all projects, although having professionals familiar with RO, considered it costly and hard work to run RO for all projects (more than 400). They considered that, for the sake of comparison, all projects must be compared by the same tool. On the other hand, in Case 2, the top executives were not familiar with RO, and they judged it hard and time-consuming to understand the RO valuation. In both cases managers were seen as undisciplined or "dreamers", losing legitimacy. In Case 5, the investors were also not familiar with RO. After a workshop explaining the RO approach and presenting in detail the valuation process, investors understood that the entrepreneurs were trying to increase artificially the value of the innovation. As a consequence, the entrepreneurs lost legitimacy and did not obtain funding.

We argue that, when actors try to do something new (in our cases, RI projects), by introducing a new way of doing it (by using RO), they may face the "newness prison". We term it as a prison because of the difficulty of altering the following problematic situation: other actors, responsible for the evaluation of RI managers' performance or important for decision-making regarding their work, do not fully understand the process of RO and do not legitimate the nature of their activity or the process necessary to do it. These external actors might not understand that trial-and-error learning, including failures, are part of journey. Although the importance of RI is commonly recognized nowadays, there is no widespread understanding that RI requires special non-standard mindsets and approaches, for both valuation (Christensen et al., 2008) and for the overall management system (O'Connor et al., 2008). As a consequence, using traditional approaches, such actors perceive most RI projects as not viable and their managers as undisciplined for requiring special rules for their work. This whole situation leads to the loss of RI legitimacy. Our cases also reveal that, even though facing the loss of legitimacy, some managers decided to keep searching for RO, aiming to mitigate the "newness prison". In the following sections, we explain the reasons why some managers still search for RO.

5.3. RO structuring

Coff and Laverty (2007) argue that the "Real Options approach must incorporate specific processes and structures; it is not simply a valuation technique". In this line, our research shows that some managers search for RO as a new way of structuring RI projects. Managers struggle to frame a project related to exploring a radical innovation for many reasons. First, RI projects involve a considerable amount of uncertainties regarding technology, resources, market, and organization (Rice et al., 2008); without proper approaches and tools, it becomes hard to cope with uncertainties. In this vein, managers face challenges to understand how to deal with uncertainties. This situation has led some scholars to investigate new ways to organize and manage radical innovation (Leifer et al., 2000; Paulson et al., 2007; O'Connor et al., 2008; Kelley et al., 2011). Second, leading on from the above-mentioned issue, managers face difficulties in clearly identifying stages and gates; traditional stage and gate approach hardly fit to RI, as pointed out by O'Connor (2008) and Salerno et al. (2015). Third, managers search for an understanding of how the emergence of new information and knowledge might affect a project's scope and plan, and the value of innovation. Since traditional valuation tools are not useful for coping with these challenges, managers search for alternative approaches to structure RI projects (as pointed out by Meyer et al., 2002). We argue that managers search for RO independently of the valuation itself; the RO approach is sometimes seen as a way to structure RI projects, in the search for:

5.3.1. Framing the idea

RO may help to frame a project related to RI in several ways. First, when managers are able to predict the phases of project development, RO interprets such phases as options, helping to make explicit the key decision points for exercising a given option; firms have the right, not an obligation, to keep investing in a given option. The RO approach indicates that, owing to uncertainties regarding a critical technological feature (e.g., productivity), different market payoffs can be achieved, as we have seen in all five cases. The building of option trees, when possible, helps to identify critical technological uncertainties that shape market performance. Although it can be argued that other tools are better for the task, and although it is only possible to build a tree if there is some confidence in the possible paths and decisions that will be taken in the future, the option tree is a strong visual tool to communicate the alternatives, progress and possibilities of failure. This sort of tool provides an important source of information to the RI team and makes it clear to the firm how the mitigation of uncertainties is related to the value of the projects.

5.3.2. Planning the idea

because RO helps to frame the project path as a set of options, it also helps to define the scope, sequence (following an option tree instead of a linear path), budget (with early commitment at the beginning) and duration.

5.3.3. Applying a learning and dynamic perspective

the RO approach provides a way of understanding and dealing with the learning resulting from uncertainty mitigation and the emergence of new information and uncertainties. The option tree, as a visual tool, helps managers to reframe the project when new information and uncertainties arise. For instance, in Case 5, new knowledge regarding the technology evolution led to the identification of new options (the acquisition of technological startups, exploring new technological options), not previously considered at the beginning of the project.

We term the possibilities of framing the idea, planning the idea, and applying a learning and dynamic perspective as RO Structuring. This consists of applying RO modeling (identifying options to be taken) to frame and plan the sequence of options, the gates as decision points, duration and budget of a project, in a dynamic and learning approach. Managers in Cases 1, 2, and 5 considered RO Structuring as a means to complement traditional project management.

5.4. RO integration

Our cases also reveal that the search for RO hides the need to integrate different levels and perspectives, such as project management, innovation portfolio management, and strategy. As mentioned, managers using RO faced the "newness prison". To mitigate this problem, initially, managers learnt more how to use RO and develop RO as a way of structuring RI projects. This accumulation of knowledge was not enough to solve the "newness prison". As a complement, managers also tried to use RO as an integration approach, involving some aspects, such as:

5.4.1. Communication

A critical challenge we identified in the cases was how to communicate aspects related to RI projects to relevant members in the organization. Tacit and intangible aspects, the presence of uncertainties, and the need to change directions in a project are ongoing challenges according to the interviewees. We interpreted the search for RO as way to communicate the progress of a project. RO provides a set of new codes (e.g., option trees, flexibility), symbols and templates to communicate RI projects at the project level (i.e., among managers and team members), the portfolio level (among members of the portfolio committee), and the strategic level. For example, in Case 1, RO helped managers to explain why and how the emergence of new information (knowledge and uncertainties), regarding the technology, demanded the reframing of the project and the creation of new options; in Case 5, it helped the project manager to bargain with higher managers.

5.4.2. RO mindset x RI mindset

Except for the startup, an important challenge was to create a proper mindset regarding RI in the organization. For example, in Case 5, a senior manager explained that the mindset regarding incremental innovation was well established: organizational members shared a common understanding of what good management of incremental innovation was (e.g., avoiding delays, achieving quality requirements, budgeting, etc.), while there is a "gap" in relation to RI. The same applied for Cases 1, 2 and 3. We argue that the RO mindset refers to a common set of heuristics, shared by organizational actors regarding the use of RO to RI, how RO works, and when to apply it. For instance, at the portfolio level, the discussion of projects involves the identification, analysis and creation of options. In Case 1, managers expected RO to allow them to have more strategic discussions during portfolio meetings. In the development of a new biomass, the managers expected to employ RO to discuss different progression strategies, such as the acquisition of startups and patents. With a proper mindset, the members of the portfolio committee would be able to treat the meetings, not as checklists but as an opportunity to create and exercise more substantial options. In Case 5, managers expected RO to allow the portfolio committee to better understand setbacks, delays, re-planning, and failures inherent to more uncertain projects.

5.4.3. Progressive resource allocation

It is possible to plan budgets for incremental innovation projects at their very beginning. The same is not true for radical innovation projects, since uncertainties mean it is often unclear what resources may become necessary for their development, calling for a progressive resources allocation (Klingebiel and Adner, 2015). While a RO mindset refers to a cognitive aspect of integration, "progressive resource allocation" refers to a process which may be implemented at the portfolio and project levels. Managers in Cases 1 and 2 expected the resource allocation of projects to assume a more progressive approach, instead having a steady or "all we need we should know at the beginning" approach. Obviously, even in incremental projects, expenditures are not concentrated at the beginning, but project valuation requires the prediction of all expenditures. The search for progressive resources allocation refers, in fact, to the need of a different approach for RI project evaluation, which does not compare RI projects against incremental innovation. In the beginning of an RI project, managers search for low resource commitment. With new learning and the mitigation of critical uncertainties, managers are expected to have the flexibility to increase the investment. Although such understanding sounds reasonable to portfolio committees, its effective implementation demands an important change in the way budgets are defined and modified.

5.5. Illustrative propositions, implications to theory and practice

In the previous sections, we sketched the problems and processes that emerged from our data through which to explain the reasons why managers search for RO. These findings suggest the corresponding propositions:

Proposition 1. Firms search for "RO valuation" to deal with the "paradox of organizational fit".

Proposition 2. Firms implementing "RO valuation" have to deal with the "newness prison".

Proposition 2.1. Firms search for RO Structuring to mitigate the effects of the "newness prison".

Proposition 2.2. Firms search for RO Integration to mitigate the effects of the "newness prison".

Based on these findings, we argue that our study has some implications for theory. Our core theoretical contribution consists of a framework that explains why firms search for RO to evaluate RI projects that have high uncertainties. The real issue is not RO, but the elucidation of the questions behind the search for it. First, a key contribution is a reinvigorated view of the legitimacy role in implementing innovation in management and in the RI management system, conceptualized in our research by the "paradox of organizational fit" and the "newness prison". While innovation in management indicates that managers try to increase their legitimacy by introducing new practices (Mintzberg, 1973), our research shows that when and why this search for legitimacy emerges and highlights the "paradox of organizational fit". Second, we also extend the understanding of the challenges faced by firms that start to carry out RI projects. An in-depth field study such as ours identifies that current mindsets lead managers to carry out RI projects (something new) by employing their firm's established processes, suitable for incremental innovation. Although decades of scholarship have shown that traditional approaches of valuation and project management are not suitable for RI (Christensen, 1997; Huchzermeier and Loch, 2001; Santiago and Bifano, 2005; O'Connor et al., 2008), our study reveals that managers try to apply such approaches in order to facilitate analysis and performance evaluation of RI projects by other company members. In our cases, managers explicitly or implicitly recognized that doing something new by using known approaches would increase their legitimacy. Our findings show that managers faced, in turn, a decrease in their legitimacy due to setbacks and failures usual in RI projects. Third, our findings also extend the theories on management innovation (Birkinshaw et al., 2008) and RO by showing that the introduction of RO to perform RI projects might lead managers to face the "newness prison". Then, our research reveals why managers still search for RO, even when they are facing the "newness prison".

Fourth, we contribute to the RO literature (Huchzermeier and Loch, 2001; Barnett, 2005; Coff and Laverty, 2007; Tong and Reuer, 2007; Klingebiel and Adner, 2015). Our in-depth cases reveal the reasons why firms search for such an approach, and the very limitations of it for valuating RI projects. RO, indeed, is not only a valuation tool, it also touches specific organizational aspects (Coff and Laverty, 2007; Trigeorgis and Reuer, 2017), which are better stated and enunciated by what we call RO Structuring and RO Integration.

Our findings involve aspects operating in two domains: processual (i.e., progressive resource allocation, RO Structuring), and

cognitive (i.e., RO mindset, communication). These aspects also complement and help to bridge two separate literatures: RO Reasoning (Klingebiel and Adner, 2015) and RO as valuation tool (Huchzermeier and Loch, 2001).

Our study has some relevant implications to practice. Those with the task of managing RIs in large firms should pay attention to the "paradox of organizational fit" and entrepreneurs should also pay attention as to whether their investors fully understand what they are pursuing. The "newness prison" might lead entrepreneurs to face an erosion of investors' trust or, in more extreme cases, early failure. Similarly, managers should analyze if the search for RO is causing the "newness prison", and, if this is the case, employ RO Structuring and RO Integration as a mitigation process.

6. Conclusions

Our research reflects on a significant problem of contemporary management, the valuation of innovation projects with high uncertainty. Valuation itself has many theoretical, methodological and practical issues. We have highlighted that, in many cases, the valuation issue hides broader organizational and managerial aspects related to RI management and legitimacy.

By in-depth case studies analysis, we argue that managers search for RO as a form to deal with the "paradox of organizational fit". When implementing RO, however, they may face the "newness prison". RO Structuring and RO Integration are alternatives to mitigate such problems.

Our research has some limitations, which can be seen as opportunities for further research. First, the limited number of cases. Second, caution is required in not confusing RO as a valuation tool and RO as an aid to structure projects. We highlight the problem of legitimacy in RI management, and we explore the possibilities set by RO Reasoning to counter the problem. However, RO Reasoning is not an exclusive method to contour the legitimation problem, and probably not the best. Legitimation is a complex issue, involving many aspects of the organization and its culture. Anyway, we have laid one stone to aid the building of the cathedral of RI management systems.

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