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CONFERENCE PAPER

## Multilevel approach for Real Options in the innovation management process: integrating project, portfolio and strategy

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### Synopsis

The Real Options approach used by innovative firms has been largely studied considering three different levels: strategy level, innovation portfolio level and project level. The theoretical discussion, however, is still unclear about how to integrate these three levels. The main goal is to identify how it is possible to integrate the Real Options approach on project, portfolio and strategy levels.

### Research design

Based on four in-depth case studies and on grounded research in companies in Brazil, where we have longitudinally accompanied specific projects, we propose a discussion on the main

issues behind different forms of integrating strategy, portfolio and project, using the Real Options approach.

## Relevance for practice

We believe that the integration between these three levels in using Real Options is crucial to comprehend organizational aspects and mainly to capture the value of managerial flexibility. This value is added by the Real Options approach when compared to traditional financial approaches (as net present value and return on Investment).

## Main Findings

We provide links among the issues treated separately in the literature: strategy, portfolio and project management. For instance, we show how flexibility might increase (or not) in the three levels and the alignment (or not) among these levels. We also find that the managerial flexibility should not be treated exclusively at the project level (different from the current thinking on the innovation literature) and should be considered at different levels. Furthermore, we claim that the portfolio architecture should be linked and influenced by strategic Real Options, which implies important changes in the portfolio management process.

## Research implications

Our paper also indicates the open space for the development of contingency models that aim to align the use of Real Options in the three perspectives described and the refinement of the managerial mechanisms to balance the different arrangements each level has.

## Keywords

**Real Options, Strategy, Innovation Portfolio, Project Management**

## Introduction

The use of the Real Options approach to value projects with a higher innovation content has attracted the attention of academics and practitioners in recent years (Barnett 2005; McGrath 1997; Wang & Wu 2015). To conduct this study, we adopted the concept of Real Options set by Dixit and Pindyck (1994) and adapted by Adner and Levinthal (2004, p. 75): “Real options investments are characterized by sequential, irreversible investments made under conditions of uncertainty.”

In this theme, the scholars have explored a vast agenda of research. For instance, enhancing the mathematical models to apply the approach to different kinds of innovation projects (Wang & Yang 2012); discussing the organizational aspects linked to the use of Real Options (Coff & Lavery 2007); and analysing the contributions of Real Options to understand strategic investments (Krychowski & Quélin, 2010). Furthermore, the literature has addressed the Real Options thinking in different streams of research, comprised in three different perspectives: project valuation and project management (at project level), innovation portfolio (at portfolio management level) and strategic investment management (at strategy level).

At the project level, for instance, Huchzermeier and Loch (2001) focused their work on employing Real Options as an alternative for valuating and managing R&D projects. At the

portfolio management level, Santiago and Bifano (2005) investigated how Real Options might be applied to support innovation portfolio. Paulson, Connor and Robeson (2007) proposed the insertion of Real Options logic on the elaboration of portfolio management tools. Klingebiel and Adner (2015) and other scholars looked at Real Options at the strategic level, developing analysis including not only the use of Real Options on the financial point of view but also the application of its underlying principles and logic – *Real Options Reasoning (ROR)*.

By Real Options Reasoning, we consider “a conceptual approach to strategic investment that takes into account the value of preserving the right to make choices under uncertain conditions” (McGrath & Nerkar 2004, p. 1). In this paper, we developed an approach integrating such different perspectives to support substantive and radical innovation management. This integration is necessary, once the Real Options approach has been used in several ways in the literature, thus proving its potential as a relevant project management approach (Adner & Levinthal 2004; McGrath, Ferrier & Mendelow 2004).

As consequence, the research question that guides this paper is as follows: How might the Real Options approach be integrated at the project, portfolio and strategy levels? We perform a literature review on Real Options in order to develop a comprehensive framework focused on the integration of the approach on strategic, portfolio and project levels. In addition, we conducted a multiple longitudinal case study in four Brazilian firms which pursued managerial mechanisms on their innovation management system that uses Real Options or Real Options Reasoning. After Perlitiz, Peske and Schrank (1999) pointed out the implementation issues in applying Real Options for R&D valuation and questioned why the method was not the standard in industry, Barnett (2005) and Tong and Reuer (2007) recognized that the organizational and managerial aspects of using Real Options are frontiers in this research field.

Our work contributes to a discussion of the relationships between the different levels in which the Real Options approach is used in activities with regard to innovation management. We believe that the fit between the levels of analysis in using Real Options is crucial to comprehend the implementation issues related to organizational and managerial aspects and mainly to capture the value of managerial flexibility. This value is added by the Real Options approach when compared to traditional financial approaches (as net present value and return on investment). The main goal was to identify how it is possible to integrate the Real Options approach on project, portfolio and strategy levels. In the first section of this paper, we develop a literature review on Real Options, with sections on project level, program management level and portfolio level. Then we describe the methodological aspects of the research, present the results and discuss them and at last, we conclude arguing about theoretical and practical implications of our findings.

## Theoretical background

### REAL OPTIONS AT THE PROJECT LEVEL

Because Options Theory was first set on financial markets (Black & Scholes 1973; Cox, Ross & Rubinstein 1979) and extended to the real environment (Dixit & Pindyck 1994; Luenberger 1998; Trigeorgis 1996), several scholars dedicated their work to developing new mathematical models derived from them, and applied them to different contexts. Conceptually, an option is a right, not the obligation to buy or sell a good at a point in the future. The possibility to wait for new information and make the decision more assertive generates so-called “managerial flexibility,” which can be quantified and has a specific value. The idea

considers that the uncertainty on projects' payoffs increases the value of the "Real Option" and improves the general value of that project when compared to traditional valuations based on NPV – net present value (Huchzermeier & Loch 2001).

With respect to R&D projects, and more broadly innovation projects, the development of mathematical models based on Real Options had been appointed as an adherent to value the projects, highly surrounded by uncertainties (Perlitz et al. 1999). In this sense, Huchzermeier and Loch (2001) analyse the influence of different sources of uncertainty on innovation projects and the value of managerial flexibility. Santiago and Vakili (2005) continued on the same road in developing this model, and Santiago and Bifano (2005) used an approximated model to value a development project of electronic devices. Schwartz (2004) applied Real Options to value patents. McGrath and Nerkar (2004) looked at models to use Real Options on pharmaceutical firms. More recently, several scholars have worked on elaborating models for specific markets or technologies (Wang et al. 2015; Wang & Yang 2012).

In general, at the project level the use of Real Options is focused on developing and applying mathematical models intending to capture the managerial flexibility of a project and to produce a better value than traditional alternatives predicts (as NPV) to improve decisions during the project development process. Should the project be interrupted? Improved? Abandoned? The logic behind the methods, related to the elaboration of decision trees and the identification of critical uncertainties is aligned with the needs the innovation management imposes.

## REAL OPTIONS AT THE PORTFOLIO LEVEL

The portfolio management of innovation projects has been discussed with a view to selecting projects on a portfolio and balancing resources on these projects in an optimal way (Cooper, Edgett & Kleinschmidt, 1999). The architecture of the portfolio involves considering its strategic buckets, the rules to characterize each portfolio and to rank the projects, the support to decisions and the resources re-allocation as some of the macro activities of portfolio management.

Regarding Real Options at the portfolio management level, the literature prescribes actions with respect to (i) the need for a concrete project valuation to compare different initiatives inside the same bucket and the possibility of Real Options to fit it (Cooper et al. 1999); and (ii) evaluation tools that internalize the assumptions of Real Options, but translate them to qualitative scores (Paulson et al. 2007; Terwiesch & Ulrich 2008). In this way, Mathews (2010a, 2010b) developed an algorithm and a managerial procedure based on Real Options parameters to classify and quantify pre-development ideas and product concepts.

Another stream of research focuses on developing Real Options mathematical models to optimize the project selection and to minimize risks and hedge against uncertainties. Wang and Hwang (2007) formulated the portfolio selection problem using fuzzy programming. Van Bekkum, Pennings and Smit (2009) analysed R&D projects as call options and studied the effect of project conditionality and correlation on the risk of a portfolio of projects. Lo Nigro, Morreale and Enea (2014) developed a Real Options model to select which project to finance in a portfolio, considering open innovation possibilities.

At the portfolio management level, Real Options approach is used not only to value a single project but also to analyse a portfolio of projects and support the decision-making on which the management should focus. Using analytical tools or Real Options mathematical models, the intention is to address the managerial flexibility – not that one present in one

project, but the flexibility in selecting and reallocating scarce resources between projects. The project portfolio is seen as a Real Options portfolio.

## REAL OPTIONS AT THE STRATEGIC LEVEL

A stream of research has been conducted on the use of options logic at the strategic level and is related to the strategic choices or investments an organization (McGrath & Nerkar 2004). The application of Real Options on strategy is called as Real Options Reasoning (ROR), considered as “a conceptual approach to strategic investment that takes into account the value of preserving the right to make choices under uncertain conditions” (McGrath & Nerkar 2004). The ROR considers the underlying principles that Real Options explicitly shows at the project level and translates it to a higher level of investment. As a consequence, a firm can “engage uncertainty and benefit by investing in options to respond to uncertain futures by managing the investment in a sequential fashion as uncertainty is resolved” (Tong & Reuer 2007, p. 3). Investments could be R&D, internationalization, diversification, new business development and so on.

Tong and Reuer (2007) discuss the contribution of Real Options to strategic management in three paths: (i) Real Options forces the re-analysis of the constituted wisdom and present specific predictions on a firm's choices; (ii) Real Options sets an imbalance in the structure of payoff for the potential investments that pursue options, reducing downside risks and favouring upside opportunities; (iii) Real Options influences and clear the resource allocation process of the company informing strategic decision-making.

Klingebiel and Adner (2015) and Barnett (2008) affirm that, because of the rigour and methodological complexity of Real Options mathematical valuation methods, this approach had its decision rationale of investments utilized as a heuristic and guide for management decisions and strategy formulation. Three elements of resource allocation regimes that characterize the ROR are (i) sequencing; (ii) low initial commitment; (iii) re-allocation (Klingebiel & Adner 2015). The use of options framing for decision-making under uncertainty, for instance by using small initial investments and assuming riskier projects, produces strategic flexibility, permitting managerial intervention that generates higher upside potential and contains downside losses (Barnett 2008). Instead of following the traditional decision-making framing, which indicates avoiding riskier projects, ROR drives to riskier investments; that is, in this case, uncertainty produces value.

## REAL OPTIONS FRAMING: PROJECT, PORTFOLIO, STRATEGY

Each of the three different levels of analysis in which Real Options is applied has its dynamics and managerial processes. On the other hand, innovation management, especially that responsible for the inducement of more radical management, requires a complex system that comprehends project, portfolio and strategy levels (O'Connor, Leifer, Paulson & Peters 2008). As long as Real Options is appointed as an important approach to make viable the management of innovation (Barnett 2005; Huchzermeier & Loch 2001; Lo Nigro et al. 2014), there is the necessity of a better comprehension about the relationships between the use of Real Options logic, considering a vertical court on the three levels. To permit the analysis of Real Options at the different levels, Table 1 exhibits a summary of what has been discussed in the previous sections.

Table 1 Real options at project, portfolio and strategic levels

	Logic	Source of Managerial Flexibility	Managerial Alignment
<b>Strategic Level</b>	Real Options Reasoning: low initial commitment, sequencing, resources re-allocation	Possibility to assume high potential returns in strategic investments through the containing of failing projects and taking riskier ones with controlled downside risks.	Strategic Planning and Strategic Actions
<b>Portfolio Level</b>	Re-allocation criteria to distribute resources between projects	The possibility to reallocate resources and select projects to compose optimal portfolio.	Portfolio architecture, composition and distribution
<b>Project Level</b>	Critical uncertainty identification and project modelling	Possibility to interfere on the course of the project, improving it, abandoning it or deferring it.	Sequential and “stage-gated” project management

Source: The authors

## Methodological aspects

We have proceeded to a multiple case studies. Our main research question was: how does the Real Options approach might be integrated at the project, portfolio and strategy levels?

Considering this focus, we investigate in deep the reasons why firms or, more specifically, some managers, are trying to adopted a Real Options approach, considering this three levels. We have proceeded to longitudinal studies and accompanied some projects during a large period. Regarding the methodological aspects, we followed the recommendations of Eisenhardt and Graebner (2007), Eisenhardt (1989) and Voss, Tsikriktsis and Frohlich (2002) to proceed multiple case studies, characterizing an inductive work, once we would like to build theory from empirical analysis. Because of the long time innovation projects take to be developed, we conducted longitudinal analysis, following the planning and execution of several innovation projects on four different Brazilian companies, recognized by their innovation driven actions.

The same company can have different innovation projects, some incremental, and some radical. Besides, often there are different portfolios (R&D projects, process or product improvements, etc.) and projects differently evaluated in the same portfolio (because of balancing objectives). Nevertheless, to study projects demands also to consider the company.

We intentionally selected companies with established innovation management systems and that had contact with the Real Options approach to value innovation projects. It was necessary understand how this approach was inserted on the management system and the relations for dealing with strategy, portfolio and project management. They were followed



Table 2 Research overview: cases and instruments

Case	Brief Description	Period of Research	Research Instruments/ Protocol
<b>C1</b>	Brazilian company that develops and manufactures cosmetics. Considered one of the 10 most innovative companies in the world.	2012–2015	Interviews and discussion with the innovation manager.
<b>C2</b>	German-Brazilian company that develops and manufactures components for automobiles.	2012–2015	Interviews and discussion with the VP of R&D for Brazil and the innovation manager.
<b>C3</b>	Brazilian textile company that develops and manufactures tissues	2012–2016	Interviews and discussion with the CEO and the innovation manager.
<b>C4</b>	Brazilian textile company that develops and manufactures tissues	2012–2015	Interviews and discussion with the CEO and the innovation manager.

**Source:** The authors

longitudinally during a huge research project which investigated several aspects of the management of project with high uncertainty.

To collect data from the companies, we followed their activities longitudinally among the management of specific innovation projects, participated on selection and prioritization committees, and interviewed project managers and portfolio managers using semi-structured scripts. We have researched projects in five companies, as shown in Table 2.

## Results and discussion

As the literature presented at the beginning of this work suggested, in our sample, we found firms with different capabilities associated with strategic planning, portfolio management and project management (see Table 3). We also observed that the firms have different aspects associated with the Real Options thinking and approach. In C1 and C2, the strategic planning involves scenario analysis, roadmapping process, market analysis and benchmarking and as a result, the strategic planning provides contingency plans for different markets and technology configurations. In these firms, the strategic planning was not conceived to explicitly increase the managerial flexibility (this is not an explicit concern of firms' board), but such process helps defining a temporal sequence for exploiting the opportunities, adopting well-defined

Table 3 Processes related to each level of analysis

Level of Analysis	C1	C2	C3	C4
<b>Strategic</b>	Formal strategic planning, applying scenarios and roadmaps	Formal strategic planning, applying scenarios and roadmaps	Formal strategic planning applying SWOT analysis, Porter Five Forces.	Formal strategic planning
<b>Portfolio</b>	The firm has three portfolios: new products, new technologies and new process	Different portfolios for distinct innovation portfolios (e.g. technology, product, process)	The firm has two portfolios: new products and new process	The firm has one portfolio related to new product development
<b>Project Management</b>	The firm has two processes: new products and new technologies	Different innovation process for different types and degrees of innovation	Only the new product process is formalized	The firm has a well-established process for new product development

Source: The authors

heuristics for resource allocation: following experimentation logic, the managers use low early commitment resources at the initial phases of exploiting opportunities. The opportunities are not treated as options.

Although C3 and C4 have not employed a well-structured strategic planning process, their outcomes of strategic planning also helped to define a temporal sequence for exploiting identified opportunities. At the portfolio level, we also found substantive difference among the firms. For instance, C2 has five different portfolios, include one (incubation) for exploring radical innovation opportunities. C2 also has clear rules for defining a temporal sequence for performing the projects and the allocation of resources following the logic of minimizing the losses (e.g. low early resources commitment). In three firms (except C4), there is a well-structured process for reviewing the portfolio according to the evolution of projects and the emergence of new information.

We argue the integration (link) among strategy, portfolio and project management might be related to three aspects: managerial flexibility, managerial attention and deployment of options.

Our findings support that firms have different patterns of integration (link) among the strategy, portfolios and projects about managerial flexibility:

1. The strategic planning might generate limited flexibility, consequently impacting on the capacity of portfolio and project management to improve managerial flexibility. For instance, in C4 the strategic plan does not address new business and innovation opportunities, focusing on expanding the current market position and exploiting the current resource basis. Similarly, in C3 managers do not consider, during strategic



planning, opportunities for entering into new markets. In such cases, the strategic plan compromises the breadth of options and diversification of options. In all cases, managers have difficulties in investing in riskier projects. The managers have considerable difficulties in justifying investments on the opportunities related to radical innovation projects. Strategic planning does not offer proper heuristics to experiment without compromising a considerable amount of resources. In the four cases, managers do not have a well-defined heuristics for re-allocation of resources. Also, the managerial attention on the evolution of options is underdeveloped. There are not processes for identifying, analysing and taking decisions related to the options. Strategic reviews are only analysed during review moments, and the main concerns are the budget and time scheduling.

2. Strategic planning generates managerial flexibility, but the portfolio constrains such flexibility, and vice versa. First, it occurs when there is not a fit between the breadth of options and the types of portfolios. For instance, in the case of C4, the firms had ideas related to new business models, but their portfolios involved only new incremental product development. In C2, the managers decided to create a specific portfolio for exploring more radical innovation opportunities identified during the strategic planning. This example refers to the managerial flexibility created at the strategic level and might reflect the structure of portfolios. Second, the firms might not have heuristics that allow the firm not to compromise a considerable amount of resource at the beginning of projects. In C2, the traditional approach for defining the project's budget was to consider all resources required to perform the project. Using traditional approaches, such as NPV, managers did not consider the alternative of allocating a minimum amount of resource necessary for trial-and-error learning experiments. Similarly, C3 and C4 also planned the entire project life cycle. Third, the portfolios were not aligned with strategic actions and intentions.
3. The portfolio generates managerial flexibility, but the project management constrains such flexibility. It might occur when the project follows a predefined linear sequence of activities instead of the logic of a decision tree, paying no attention to the alternatives (options) that emerge during the project life cycle. We found a such pattern in C1, C3 and C2.

The second link identified among the three levels in our cases is related to managerial attention, which involves the ability to focus on the options, to identify and analyse the emergence of information and to change the course of action. It might occur between strategic and portfolio when the update of the portfolio does lead to an update in the strategic plan (e.g. C3) and vice versa (e.g. C4). Similarly, new information is identified at the project level, and the firm has proper communication chains and decision-making processes which allow analysing the impact on the portfolio and strategy.

The third link consists of the ability to deploy the strategic action as an option (or a portfolio of options); further, each strategic option should be treated at the project level as a set of other options. The update of new options that a project generates at each decision point and the changes performed at the strategic level should be linked in a flow of information and managerial mechanisms, to permit the company to keep its coherence. Regarding this aspect, the innovation portfolio and its management should ensure that the link is built. The strategic elements define and correct distribution of projects in them in a dynamic process, guaranteeing the value of managerial flexibility at the strategic level.

## Conclusions

### IMPLICATIONS FOR THEORY

Our findings have a number of implications for theory. First, we provide links among the issues treated separately in the literature: strategy, portfolio and project management. Based on the three cases, we found that managerial flexibility, managerial attention and the deployment of options bridge these three levels. We show how flexibility might increase (or not) in the three levels and the alignment (or not) among these levels. We also show that the managerial attention might be a useful link among these levels and these required appropriated communication chains and integrated decision-making processes. The misalignment in using the Real Options approach in each of the three levels and the different comprehension each of them has about the managerial logic behind the elaboration of the options are perceptive on the treatment of each theoretical perspective put on the theme.

We also find that the managerial flexibility should not be treated exclusively at the project level (different from the current thinking on the innovation literature), and should be considered at different levels. It is clear in the literature that the use of Real Options approach to structure and manage projects produce managerial flexibility (Huchzermeier & Loch 2001), but the consideration of the possibility to change the course of the projects and the implications it has to strategy and portfolio management might be extended.

Another point we indicated is that the portfolio architecture should be linked and influenced by strategic Real Options. This implies important changes in the portfolio management process. For instance, the portfolio might be organized in different project buckets, considering the options they can generate for the company (e.g. abandoned projects, improved projects, licensed projects). The portfolio balancing logic moves from the traditional incremental versus radical projects to a Real Options logic. The rule of balancing takes into account the different strategic options the firm constituted with its projects.

At last, we argue that project management should be organized according to Real Options logic. The project sequencing might consider different options instead of a predefined flow. The project management system should include, for instance, the draw of decision trees, evaluation and decision gates, and the process of changing direction the options logic requires.

Our work indicates, in the end, the open space for the development of contingency models that aim to align the use of Real Options in the three perspectives described and the refinement of the managerial mechanisms to balance the different arrangements each level has.

### IMPLICATIONS FOR PRACTICE

Our work provides some relevant insights for practice. The disperse way Real Options are treated across different organizational levels entails the search for managerial mechanisms to link them. The strategic planning tools do not consider the presence of options, and are driven by competitive-advantage thinking. In dynamic environments, in which there is a need for taking more risky projects, this logic has no more adherence, making the Real Options approach an important heuristic for strategic formulation. To make it palpable, a competency to map strategic investments as a set of options and, more importantly, the organizational disposal to kill or abandon projects and established strategic actions are indispensable.

Translating strategic options to an innovation portfolio requires a well-designed configuration of project buckets. The buckets should address the significance of each strategic

option and support the alignment across projects in a way such that the strategy options can be visualized and achieved between them. The guarantee that each portfolio has resources and organizational protection makes the strategy possible, as the re-allocation of resources is feasible and manageable. In this sense, the link between the innovation portfolio and the strategy should be the deployment of the strategic options in buckets composed by the projects responsible for making the strategy achievable. The managerial flexibility at portfolio level only has value if the flow between portfolios occurs and if the portfolios represent specific strategic options.

Between the portfolio level and project level, the link is materialized, first, at the moment the projects are inserted in one of the portfolios, and second, when, during the sequential and “stage-gated” management of them – based, for instance, in decision trees – the decision-making directs the project to another portfolio or generates new options inside the projects. However, the project produces managerial flexibility individually, and this value only becomes real if it produces strategic value for the firm. The interaction between project and strategy levels also needs to be balanced, and the flow of projects fuelling the set of strategic options, as well as the strategic options becoming projects, may be constant and equalized by portfolio management.

Our work indicates that to migrate from the sustainable competitive advantage logic to a transitory competitive advantage, an important step is linking strategy, portfolio management and innovation project management. Real Options logic is a relevant approach to performing this task, integrating these three levels and establishing management mechanisms to produce and realize the value of managerial flexibility.

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