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A model for valuing new technologies under a pull incentives environment

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ABSTRACT

Investment in innovation and Research & Development (R&D) projects is one of the key strategies that firms need to implement to enhance growth, increase profitability and create value. On the other hand, R&D projects are characterized by significant levels of risk due to limited information and uncertainty over both the investment costs and the expected returns. In order to encourage the development of high-risk, but relevant, R&D projects, some risks can be mitigated by other project stakeholders through the use of pull incentives, such as a minimum guaranteed demand.

In this article we propose an adaptation of a real option model for valuing R&D projects where we incorporate a pull incentive for the final product using a market sales function that decreases in time and is strictly positive over the product's life cycle. We apply this model to the case of the development of a Power Line Communication modem (PLC) for Smart Grids in the Brazilian electricity market, where a power utility firm agreed to bear part of the development risk by means of a minimum guaranteed demand, and solve using Monte Carlo simulation. The results suggest that this guarantee has significant impact on the project value, which is not captured by traditional valuation methods or even real option methods that do not incorporate this concept.

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1. Introduction

Investment in innovation and Research & Development (R&D) projects is one of the key strategies that firms need to implement to enhance growth, increase profitability and create value [19,23].

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On the other hand, R&D projects are characterized by significant levels of risk due to limited information and uncertainty over both the investment costs and the expected returns. In addition, R&D projects typically present operational and managerial flexibilities which allow the firm to change strategies in order to maximize returns or minimize losses as the uncertainties are revealed in time. These managerial flexibilities, which allow the firm to enhance, delay, suspend, expand or even abandon a project as new information on its feasibility becomes available, have option-like characteristics and thus can only be valued under option pricing methods such as Real Option Analysis (ROA). An adequate valuation model of R&D investment opportunities is critical for the correct assessment of the feasibility of this class of projects.

Real Options Analysis (ROA) derives from the work of Black and Scholes [3] and Merton [18] (BSM) for the valuation of financial options. Myers [20] recognized the similarity between financial options and managerial flexibility as options on real assets, and is credited for coining the term “Real Options”. He also was the first author to suggest the use of ROA to value R&D projects, as traditional methods such as the Discounted Cash Flow (DCF) fail to capture the value of flexibility that may be embedded in these projects [11,21].

In this article we analyze sequential R&D technological projects, where a staged process allows the management to proceed to the next stage only if the expected technical and financial results of the current stage are satisfactory. We argue that there may be instances where the expected results of an R&D project are deemed sufficiently relevant that a government or a private entity may be willing to provide incentives in the form of pull (purchase commitment plans) or push (cost subsidy plans) incentives to make it financially viable [12]. With this in mind, we propose an enhancement to the Silva and Santiago [27] model and incorporate a pull incentive in the form of a minimum guaranteed demand.

Since staged R&D projects typically present many technical and market uncertainties, significant managerial flexibility and irreversible development costs, our analysis will be done under the real options approach. Although the literature on the valuation of R&D technological projects using ROA is vast [1,10,2], the ROA valuation under pull incentives we propose is a novel contribution to the field.

In order to test the model, we apply it for the development of an innovative Power Line Communication (PLC) modem for use in electrical Smart Grids in Brazil. The results suggest that the minimum demand guarantee reduces uncertainty and has significant impact on the project payoff.

The remainder of the article is organized as follows. After this introduction we present a literature review of the valuation of high risk R&D projects and, in Section 3, we present the background of our model. In Section 4, we introduce the pull mechanism in the form of a general sales function; next, in Section 5, we apply this adapted model to a real case and present the results. In Section 6, we perform a sensitivity analysis and in Section 7 we conclude.

2. Valuing high risk R&D projects

Several authors that have developed ROA models for R&D projects. Pennings and Lint [22] and Perlitz et al. [23] argue that the project value is often adjusted during the stages of an R&D process, which may lead to significant differences from the static DCF analysis. Thomke [31] shows empirically that flexibility under uncertainty allows firms to continuously adapt to enhance product performance. Therefore, ROA has become a well-known R&D project valuation technique for intertemporal risky investments [33].

ROA is the model of choice to determine the value of real-world investment opportunities where there are embedded managerial flexibilities and future expected cash flows are uncertain. As shown by Trigeorgis [32], Copeland and Antikarov [6] and others, the Discounted Cash Flow method (DCF) assumes that future cash flows are static and does not capture the value of managerial flexibility. According to Myers [20], a significant portion of corporate assets can be viewed from the perspective of a call option on these assets, or growth opportunities, where the option's exercise price is the future investment needed to acquire the asset. This consideration is particularly true in R&D projects, in which the initial investment can be seen as a payment to obtain the right, but not an obligation, to continue development.

ROA involves a greater mathematical complexity than traditional models. This is a problem of dynamic optimization, where the evolution of uncertainty in the value of the project over time is modeled as a stochastic process such as the Geometric Brownian Motion (GBM), Mean Reversion Models (MRM) or others. The project value is a solution to a value function represented by Bellman's principle of optimality, with initial conditions and terminal payoffs. Normally, closed-form mathematical solutions are unavailable for real and complex problems, when the project is subject to several sources of uncertainty or more than a single type of option exists. In such situations, numerical methods combined with discrete dynamic programing must be used to obtain a solution. These methods may use techniques such as Monte Carlo Simulation or the Binomial model originally developed by Cox et al. [7] (CRR) that converges weakly to a lognormal diffusion of cash flows. For a broader discussion of such methods, see Brandao and Dyer [4].

The CRR binomial model is usually used as a discrete approximation of Black-Scholes-Merton (BSM) continuous time valuation model for financial options, with the clear advantage of allowing a solution for early exercise American options that is not allowed in the BSM model. Both the BSM and CRR models rely on risk neutral valuation as a tool to incorporate the impact on the discount rate that the existence of any embedded project option has on the risk of the project. While all ROA methods adopt risk neutral pricing, this does not imply that the projects are risk free, merely that the risk is incorporated elsewhere in the model. In the case of CRR, this is done by substituting the objective probabilities of the payoff outcomes discounted at the risk adjusted rate by risk neutral probabilities where the payoff is discounted at the risk free rate. In the absence of options, both alternatives are equivalent.

When compared to decision trees, what can be stated is that, while decision trees have been used to model project flexibility, naive decision trees do not provide means to deal with the effect on risk brought by project's embedded options. In our case, the pull mechanism in the form of a minimum guaranteed demand reduces the risk of the project, and such reduction must be captured by the valuation model, which is not possible with naive decision trees.

Smith and Nau [28] propose a method that integrates decision trees and ROA by distinguishing between market risks, which could be valued using option pricing theory, and private uncertainties, which are project specific risks and can be valued using decision tree analysis techniques. In the present work, we aim to combine such techniques in order to deal with market and private risks of our project.

Brandao and Dyer [4] highlight the distinction between market risks and project specific risks using an example from the oil industry: while prices and demand for oil are market risks, exploration uncertainties are project specific, or private risks. While market risk command a risk premium, private risks are considered risk free for a well-diversified investor, as they are uncorrelated with the market. Although it is not trivial to separate market risks form private risks in many projects, in R&D projects this usually can be done. In our work, we will consider the