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Valuation of project portfolios: An endogenously discounted method

Juan C. Zapata, Gintaras V. Reklaitis *

School of Chemical Engineering, Purdue University, 480 Stadium Mall Drive, West Lafayette, IN 47907, USA

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ABSTRACT

Real options analysis (ROA) has been developed to value assets in which managerial flexibilities create significant value. The methodology is ideal for the valuation of projects in which frequent adjustments (e.g. investment deferral, project scope changes, etc) are necessary in response to the realization of market and technological uncertainties. However, ROA has no practical application when valuing portfolios of multiple concurrent projects sharing resources, as the size of the problem grows exponentially with the number of projects and the length of the time horizon. In this paper an extension of ROA suitable for the valuation of project portfolios with substantial technological uncertainty (e.g. R&D portfolios) is proposed. The method exploits the distributed decision making strategy encountered in most organizations to decompose the portfolio valuation problem into a decision-making sub-problem and a set of single project valuation sub-problems that can be sequentially solved. Discrete event simulation is used for the first sub-problem, while a tailored ROA based strategy is used for the set of valuation sub-problems. A case study from the pharmaceutical industry is used to compare the decision tree analysis (DTA) method and the proposed method.

1. Introduction

In technology based industries, innovation is one of the most if not the most important factor that affects the future financial performance of a company. A significant portion of the new technologies brought to market by these industries are internally developed by their research and development (R&D) organizations. Therefore, the efficient and effective selection and management of the portfolio of R&D projects is essential to ensure the company's ability to compete and grow. Though different strategies to select and prioritize projects in an R&D portfolio examine particular combinations of performance measures (Zapata et al., 2008 and references hereafter), all of them incorporate in one way or another measures of financial performance. The commonly used financial valuation strategies for real assets (e.g. companies, portfolios or projects) are mainly based on the standard application of net present value (NPV) and decision tree analysis (DTA) concepts (Hartmann and Hassan, 2006; Ryan and Ryan, 2002). In spite of the advantage of DTA over NPV due to its ability to capture managerial flexibility, it is criticized for the use of a single discount rate (e.g. weighted average cost of capital (WACC)) to characterize the asset's risk profile in time (Copeland and Antikarov, 2001; Dixit and Pindyck, 1994; Trigeorgis, 1996). The resolution of uncertainties and the corresponding response of management result in changes in the cash flow patterns that modify the asset's risk profile, requiring, to avoid the creation of arbitrage opportunities, the use of multiple risk adjusted discount rates that can match the different states experienced by the asset. The need to develop a valuation strategy capable of computing endogenously state-based discounted cash flows led to development of ROA. ROA is a technique that conceptualizes managerial decisions as financial options (e.g. put and call options on stocks prices), and uses the methodologies developed by the financial community in the area of contingent claim analysis to value them.

As it will become evident in the next section, in academia as well in industry, the use of ROA has been mainly concentrated on the valuation of individual projects, and when applied to portfolios the focus has been on the relative comparison of projects under the assumption that they are independent. However, the resources required by projects in a portfolio are typically shared and limited. Moreover, projects use related technologies and compete in the market, which creates project interactions that make the flexibilities available to management within each project contingent on the states of the rest of the projects in the portfolio. This situation leads to actual financial portfolio performances that differ from those estimated by simply adding the value of each project when considered in isolation. Though conceptually the application of ROA to portfolios is straightforward, from an implementation perspective the combinatorial nature of the resulting problem makes it an unviable alternative. In addition, from a strategic decision making perspective a portfolio selected under the assumption that flexibilities are ideally executed (as it is done in ROA) could be

* Corresponding author. Tel.: +1 765 494 9662; fax: +1 765 494 0805.
E-mail addresses: zapata@purdue.edu (J.C. Zapata), reklaiti@ecn.purdue.edu (G.V. Reklaitis).

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suboptimal when actually developed. In this work the combination of discrete event simulation and a ROA based valuation strategy is explored as a way to address some of these limitations in order to properly estimate the value of R&D portfolios. The fundamental idea is to break down the problem in such way that the impact on the portfolio cash flows due to the use of shared resources and the local suboptimal execution of managerial flexibilities is fully captured in the simulation, while the simulated cash flows are aggregated and brought into an ROA framework to be discounted.

The rest of the paper is organized as follows. Section 2 reviews the literature that is relevant to the problem. Section 3 provides an overview of the ROA methodology and highlights its limitations when directly applied to portfolios. The proposed approach and the underlying fundamentals are presented in Section 4. Section 5 describes a case study representative of the pharmaceutical industry and compares the values estimated for a set of portfolios using the proposed approach and a simulation based version of the conventional DTA methodology. Finally, concluding remarks and perspectives are presented in Section 6.

2. Literature review

Most of the ROA literature highlights the advantages of the methodology in comparison with the NPV and DTA approaches (Copeland and Antikarov, 2001; Dixit and Pindyck, 1994; Trigeorgis, 1996). The NPV approach is usually depicted as incapable of capturing managerial flexibilities at all, while DTA is regarded as capable of accurately representing flexibilities, but unable to discount the asset's cash flows with risk adjusted rates that properly match its risk profile. Jagle (1999) provides an exceptionally clear characterization of the limitations of DTA and the reasons why they are commonly overlooked. He states that there is the tendency to believe that the changes in the asset's risk profile are captured by the adjustments to the cash flows through the use of cumulative probabilities, and that the use of a risk adjusted rate results in double counting. He draws a parallel with the capital asset pricing model (CAPM) to highlight that probabilities and discount rates represent different types of risk. In the CAPM the probabilities reflect the asset's specific risk, which theoretically is completely diversifiable, while the discount rate reflects the asset's systematic (non-diversifiable) risk. However, the NPV and DTA methodologies commonly portrayed as inferior to ROA are in reality simplifications of more general valuation frameworks. The ground-breaking work of Smith and Nau (1995) and De Reyck et al. (2008) showed that NPV, DTA, and ROA are just different interpretations of the same valuation strategy. Moreover, the frameworks developed by these researchers (hereafter referred as endogenously discounted NPV/DTA) are more general than ROA, as they solve not just the investment problem (i.e. how to develop and manage real assets), but also to the financing problem (i.e. how to borrow funds and trade financial assets to support the development of real assets).

ROA methods can be broadly classified into continuous and discrete (Perlitz et al., 1999) according to the paradigm used to represent the evolution in time of the model's input variables (e.g. project value, option exercise price, etc). Though much of the ROA related research work has been focused on continuous models (Newton et al. (2004) provide a complete summary of the efforts in the area), this literature review focuses on discrete methods. Discrete methods have the ability to incorporate almost any type of input variables and parameters (Perlitz et al., 1999), rendering them more suitable for the discrete event simulation based strategy proposed in this paper. In addition, its relative simplicity and transparency (Copeland and Tufano, 2004) makes them more attractive to practitioners. In terms of its choronological development, it is important to highlight the following works: Herath and Park (1999) use a discrete binomial model to value the development of a new product in the consumer goods industry. Jagle (1999) and Kellogg and Charnes (2000) developed binomial models to value companies and projects in the biotech industry, respectively. Copeland and Antikarov (2001) use a quadranomial model to keep technological and market uncertainties separated, and apply it to a project in the context of new drug development. Finally, Boute and coworkers (2004) highlight the potential of binomial models for project management.

All of the efforts mentioned above support theoretically or empirically the importance of capturing managerial flexibility in order to properly value development projects. However, they are limited to a single project or the relative comparison of projects assumed to be independent. Therefore, the approaches proposed are not suitable to handle the increasingly important portfolio management problem (Girotra et al., 2007; Hans et al., 2007) as they don't address the two main shortcomings exhibited by ROA in this context, namely, the curse of dimensionality and the difficulty in capturing project interactions (Faiz, 2001). Though some efforts have been made to enable discrete models to handle the additional degree of complexity encountered when considering multiple interacting projects, the proposed approaches have significant limitations. Rogers et al. (2002) studied a portfolio of drug development projects in which abandonment is the only option considered and the projects are connected through a budget constraint. The budget constraint uses the notion of overbooking and is enforced at every point in time along the time horizon. That is, the budget constrained is the expected value of the expenses of all the possible scenarios at each point in time, a concept that completely defeats the idea of capturing managerial flexibility and its effects on the portfolio cash flows, given the specific state of the portfolio and the market. Wang and Min (2006) developed a methodology for valuing a portfolio of power generation projects that are market correlated. Though market correlation is a very significant source of interaction in capacity (expansion/contraction) related portfolios, in R&D portfolios it is completely dominated by resource constraints and sometimes technology and market related interactions (e.g. similar product platform). In addition, Wang and Min's work does not address the curse of dimensionality created by the combinatorial nature of a portfolio.

It is important to highlight that in spite of the fundamental advantages of ROA, practitioners are reluctant to adopt it, even for the valuation of single projects (i.e. outside a portfolio context). Finance functions perceive the technique as complex and usually lack working knowledge to apply it, while decision makers perceive it as lacking transparency (Hartmann and Hassan, 2006). However, it is evident that the main implementation barriers of ROA (and by extrapolation of any other endogenously discounted valuation method) are not related to the fundamental principles of the methodologies or their reliability. This, in conjunction with the importance given to the conceptual use of real options (Bowman and Moskowitz, 2001; Busby and Pitts, 1997; Hartmann and Hassan, 2006; Loch and Bode-Greuel, 2001) and limited empirical data that shows the superior match between the values obtained from ROA (compared to the ones from conventional NPV/DTA) and actual project values (Copeland and Antikarov, 2001 and references hereafter; Jagle, 1999), highlight the potential of endogenously discounted methods to enhance the valuation process. The work presented in this paper is aimed to make possible the realization of this potential, from an implementation perspective, for portfolios where project interactions are driven by resource constraints and decisions are local and suboptimal. The proposed method overcomes the curse of dimensionality exhibited by ROA in a portfolio context through the combined use of discrete event simulation and a ROA based valuation framework.