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Fuzzy pay-off method for real options: The center of gravity approach with application in oilfield abandonment

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Abstract

This paper presents the CoG-FPOM, an adaptation of the Fuzzy Pay-Off Method (FPOM). The FPOM is a scenario-based real option valuation method that uses fuzzy numbers as possibility distributions. The paper shows that there are situations in which the original FPOM calculates the real option value to be negative, what is theoretically incorrect. The cause is related to the method used for obtaining a single representative value out of a fuzzy number. Instead of the possibilistic expected value operation used in the original FPOM, the CoG-FPOM uses the center of gravity (CoG) to accomplish the task – a proof of its general validity is presented. An application to calculate the abandonment real option for petroleum producing fields shows that the proposal can be easily used for project valuation under uncertainty.

Keywords: Possibility theory; Fuzzy Pay-Off Method; Real option; Center of gravity; Oilfield abandonment

1. Introduction

In today increasingly complex world, uncertainty is present in most of the decisions that should be made by companies. Nevertheless, the traditional valuation methods typically utilize a single static mean value to support decisions, commonly using discounted cash flow (DCF) analysis and net present value (NPV) [1]. Besides having parameters difficult to estimate, those techniques do not consider less likely possibilities (potentially with high impact) in the

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analysis. In order to deal with the uncertainty – and the flexibilities – that this can offer to the decision makers, the real option (RO) analysis shows up as an important valuation tool.

RO valuation is a methodology that highlights the value of managerial flexibility to respond optimally to the uncertainty. By observing that corporate investments opportunities can be viewed as financial call options on real assets, Myers coined in 1977 the term "real options" [2]. A real option is a right – not an obligation – to take an action on an underlying nonfinancial, real asset. The action may involve postponing a decision until a future time, abandoning, expanding or contracting a project, switching the input (e.g., a thermoelectric that can use gas or diesel to run) or the output, etc.

Tourinho developed the first RO mathematical model in 1979 [3]. Dixit and Pindyck published the first textbook in 1994 [4]. They pointed out the irreversibility, timing and uncertainty as key RO elements. The irreversibility (partial or total) increases the value of the "wait and see policy". The timing to exercise the option is then crucial to maximize the investment opportunity. The greater the uncertainty, the greater the value of flexibility, which is named the real options value when applicable to real assets investment. Dias [2] gives an overview of different real options models applied to petroleum assets.

Collan, Fullér and Mezei [5] point out that RO may be seen both as a qualitative method, like a mental model to analyze options for operational and strategic decision-making, and as a quantitative method, like a tool to perform numerical analysis for valuation purposes. The commonly used models for computing the real option value are based on the methods that have been used to value financial options: differential equation-based, especially Black–Scholes option pricing formula [6]; lattice-based, especially the binomial option valuation method [7]; and simulation-based methods, as the early example presented by Boyle [8].

Most of these models are complex and are based on the assumption that they can accurately mimic the underlying markets. This assumption may hold for some financial securities – like stocks and currencies, which are quite efficiently traded –, but may not hold for real investments that do not have existing markets or whose markets don't exhibit even weak market efficiency [5]. An additional observation is that the traditional methods require the uncertainty to be typically of the parametric type, not considering structural or procedural uncertainty [9].

According to Favato, Cottingham and Isachenkova [10], RO research took the direction of searching for more sophisticated statistical models, increasing the complexity of calculus instead of focusing on management relevance. In the same direction, Mathews, Datar and Johnson [11] argue that the field of RO has been slow to develop because of the complexity of the techniques and the difficulty of fitting them to the realities of corporate strategic decision-making.

In favor of blending scenarios into RO valuation, Favato, Cottingham and Isachenkova [10] say that companies should not be restricted to single forecasts, which are like predictions; instead, scenarios should be used as speculative descriptions of possible outcomes for the future, widening the chances of capturing potential opportunities and threats. By encouraging managers to envision future states of the world, scenario planning is a strategic management tool primarily used for qualitative analysis. If combined with RO, however, scenario planning may contribute to powerful quantitative assessments. In this way, decision-makers can work with a flexible valuation tool that is easy to understand and which can be lightly re-executed any time after the first decision is made – for example, when new information become available. This approach also allows for using separate risk adjusted discount rates for different cash flow items – like operational revenues, operational costs and capital investment – thus better representing the different types and levels of uncertainty within a project.

There are two main scenario-based methods for RO valuation: the Datar–Mathews method (DMM) [11] and the Fuzzy Pay-Off Method (FPOM) [5]. They both use forecasted projections for cash flows to derive a distribution of NPV for the project. While DMM uses simulation to generate a probability distribution and its associated probabilistic expected value, FPOM utilizes the possibilistic expected value out of a fuzzy number. Favato, Cottingham and Isachenkova [10] show that, all else equal, the application of FPOM is feasible and useful without the necessity to engage in high-level and daunting mathematics.

The objective of this paper is to present an adaptation of the original FPOM for RO valuation, which uses the center of gravity (CoG) and was thus named CoG-FPOM. Section 2 briefly discusses fuzzy sets and the original FPOM. Section 3 shows the unexpected results found within the original FPOM and presents the CoG-FPOM, including a proposition and its proof, which demonstrate the consistency of the proposal. Section 4 presents an application of the model in the abandonment decision of petroleum producing fields. Section 5 finalizes the paper with conclusions and suggestions for future works.

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