



A fuzzy approach to R&D project portfolio selection [☆]

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Abstract

A major advance in the development of project selection tools came with the application of options reasoning in the field of *Research and Development* (R&D). The options approach to project evaluation seeks to correct the deficiencies of traditional methods of valuation through the recognition that managerial flexibility can bring significant value to projects. Our main concern is how to deal with non-statistical imprecision we encounter when judging or estimating future cash flows. In this paper, we develop a methodology for valuing options on R&D projects, when future cash flows are estimated by trapezoidal fuzzy numbers. In particular, we present a fuzzy mixed integer programming model for the R&D optimal portfolio selection problem, and discuss how our methodology can be used to build decision support tools for optimal R&D project selection in a corporate environment.

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1. Introduction to R&D management

Usually, new production technologies are developed infrequently, and they often evolve in uneven pace. Innovations are unpredictable, and thus involve large uncertainties with respect to both the development of opportunities in existing product markets and those in production processes. Corporate R&D management, supporting the maximal use of new innovations and technologies, always tries to keep the company up with the pace of technological development. R&D projects are tools for the company's management to outpace competitors and obtain new information about promising technologies and methods. With such new information, companies aim to defend and build sustainable competitive advantages [25].

Due to their proactive nature, R&D projects are sometimes hard to evaluate. It is often the case that information required for the valuation is actually revealed gradually during the project, and at the beginning of the development opportunity there are no cash flow estimates available that would either justify or invalidate the evaluation of the project. In a sense of information quality, knowledge about the project's profitability is seldom precise, let alone that sometimes it is not even measurable. However, even in such situations the R&D management has to commit itself to either a positive decision to launch the project, a negative decision to abandon the project, or, which seems most plausible, a decision to wait and see if the information quality improves as time passes. This management position can be described as if the management had some information *hidden* or in *shadow*, and it had to make a decision about consuming some resources in order to uncover the information. The decision to use resources for information retrieval leads to the launch of the investment, when the *option to start* the project is used. On the other hand, the decision to deny resources leads to the abandonment of the underlying investment, when the *option to abandon* the project is used. Finally, the decision to stand by and wait for new information leads to *waiting* and *deferring* the investment opportunity, where both the option to start and the option to abandon are kept alive. In the absence of *quantitative* value-based statements represented by the cash flows, the R&D management often relies on *qualitative* statements made by the technological experts.

In the framework of R&D portfolio selection with real options, this kind of a management approach has a natural appeal. In 1993, Bowman and Hurry described how strategic management can be represented in the light of option theory [4]. Following their approach, we can view a strategic management process as a chain of options, where options have not been identified and are not known initially; this type of options are called *shadow options*. They become *real options* when real assets and the possible future use of real assets get connected to the options of starting R&D projects. With real options, the management has tangible strategic alternatives, such as real investment possibilities or joint ventures that can be exercised or put aside until a better time for entering into. In the case the strategic real option is expected to supply no further options, or the options are extinguished by the changes in the markets and technologies, the strategy is annulled. However, if the launch of the project supplies further options or managerial flexibility, the management can commit itself to either a strategy of *incremental continuation* or a strategy of *radical change*.

R&D management has several common features with strategic management. It actively aims at utilizing possibilities supplied by new technologies and innovations in business operations. Similarly to strategic management, R&D management also has to define objectives for the R&D operations. Following the basic R&D management approach,

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