ABSTRACT

In today's highly competitive marketplace, selecting an appropriate set of projects from a portfolio of candidate projects is vital for enterprises. An accurate selection of projects can steer a company to great success, while a careless selection may lead it to bankruptcy. Variability of project parameters such as benefit, cost, risk (failure probability), etc. during planning horizon makes this selection more complicated and increases the importance of an elaborate analysis. In this article, we studied a multi-objective R&D project portfolio selection problem. There is a conflicting desire to maximize expected net benefit and minimize risk in companies. From a novel perspective, the authors considered repetitive projects and variable amounts for aforementioned project parameters during planning horizon that could be an effect of sanctions, in our model that are features of real world problems. Due to NP-hardness of the problem and its high computational effort especially when the number of projects grows, we solved test problems of different sizes using a Multi-Objective Differential Evolution (MODE) algorithm to find pareto optimal solutions.

Keywords: Multi-Objective Differential Evolution, Multi-Objective Optimization, Project Interdependencies, Research and Development (R&D) Portfolio Selection, Uncertainty

INTRODUCTION

Nowadays, in the highly competitive and globalized marketplace, it’s a necessity to be dynamic, willing to change and innovative in presenting new products. Innovation is one of the significant key strategies for high technology firms to survive. Thus, research and development (R&D) has a critical role in successful performance of these firms. The portfolio selection is one of the most important strategic decision processes in the
definition stage of a project (Deng & Li, 2010; Jianguo & Liang, 2011). Its main purpose is to choose certain group of projects from candidate ones according to some objectives, such as company developing strategies, project investments, project returns and the risks. There are many different techniques that can be used to estimate, evaluate, and choose project portfolios. Some of these techniques are not widely used because they address only some of the above issues, they are too complex and require too much input data, they may be too difficult for decision makers to understand and use, or they may not be used in the form of an organized process (Ghasemzadeh & Archer, 2000). R&D project selection methods can usually be placed into one of the following categories (Henriksen & Traynor, 1999):

- Unstructured peer review;
- Scoring;
- Mathematical programming, including integer programming (IP), linear programming (LP), nonlinear programming (NLP), goal programming (GP), and dynamic programming (DP);
- Economic models, such as internal return rate (IRR), Net present value (NPV), return on investment (ROI), Cost-benefit analysis, and option pricing theory;
- Decision analysis, including multi-attribute utility theory (MAUT), decision trees, risk analysis, and the Analytic hierarchy process (AHP);
- Interactive methods, such as Delphi, Q-sort, Behavioral decision aids (BDA), and Decentralized hierarchical modeling (DHM);
- Artificial intelligence (AI), including expert systems and fuzzy sets;

The decision quality has great influences on the benefits and the efficiency of the use of resources of the company (Martino, 1995). However, there are two key obstacles for this process: (a) Incomplete and unreliable information which is caused by future events and opportunities that the decision process has to deal with, and (b) difficulties in tradeoffs which are caused by the multi-objective decision making process (Bagloee & Reddick, 2011; Das, Sarkar, & Ray, 2012; Jajimoggala, Kesava Rao, & Beela, 2011; Jajimoggala, Rao, & Beela, 2010; Michalopoulos, Georgiou, & Paparrizos, 2009; Nooraie, 2011; Sodenkamp & Suhl, 2012; J. Wang & Hwang, 2007).

Due to the great importance of project portfolio selection for companies and organizations, many works have been done to tackle the problem since 50 years ago and it attracted a great attention to deal with the R&D project portfolio selection in recent years. In the following of this section we reviewed some recent papers since 2000 that studied R&D project portfolio selection:

Henriksen and Traynor (1999) presented an improved scoring technique for R&D project evaluation and ranking that incorporates tradeoffs among evaluation criteria. The resulting figure of merit was then combined with a scaled funds request to obtain a value index for each proposed project. They considered risk, resource constraints such as human and budget, and decision-maker preferences in their single objective model. Linton, Walsh, Kirchhoff, Morabito, and Merges (2000) showed the advantages of using both an objective and subjective method for solving the problem. The objective measure divides the portfolio of projects into three subgroups: accept, consider further and reject. In a single objective model, they considered risk and budget constraints. Furthermore, they incorporated decision-maker preferences in their multi-criteria decision-making method. Beaujon, Marin, and McDonald (2001) rendered a quantitative tool to support decision-making in R&D project portfolio selection. Their mixed integer programming model and its linear programming relaxation can be used to effectively optimize a measure of portfolio value while considering projects interdependencies, project lead times and resource constraints.

Kuchta (2001) considered a problem of selecting a subset of indivisible projects maximizing the global Net Present Value (NPV) in which the NPV of individual projects and their resource utilization is known only in a fuzzy

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