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Project portfolio selection via harmony search algorithm and modern portfolio theory

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Abstract

Since the success of all organizations depends on aligning their projects with strategic plan of theirs, selecting appropriate project portfolio is a key decision in the path to fruitful and thriving organization. Modern portfolio theory (MPT), proposed by Harry Markowitz, attempts to maximize portfolio expected return for a specific amount of risk or equivalently, minimize risk when the expected return is specified. In this paper we first go through the literature of the portfolio selection. Secondly, the definition and mathematical formulation of modern portfolio theory is presented; thirdly in the next section the fundamental of classic harmony search algorithm (a metaheuristic algorithm) is illustrated, and finally, the numerical example of solving a benchmark problem of project portfolio selection and its results is presented. Provided results demonstrates that this algorithm solves the hard problem to almost optimality faster and robuster than other exact algorithms.

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Keywords: project portfolio selection; modern portfolio theory; harmony search algorithm; metaheuristic.

1. Introduction

Today, organizations should opt for appropriate portfolios of projects to advance their goals. Generally speaking, there are so many projects that an organization cannot fund or support. Ideally, corporate managers try to choose an optimal subset of projects to meet the corporate`s goals while satisfying budgetary constraints and restrictions. On the other hand, they try their best to refrain from the overall risk of a portfolio of projects and ensure

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that return of their investment or other such objectives are maximized (Better and Glover, 2006). Organizations are often confronted with having more projects to choose from than the resources to carry them out and thus one of the main management tasks is to select from an array of projects those better adapted to the organization's objectives (Ghasemzadeh F. et al. 1999). Wrong decision making in selecting projects of a portfolio has two negative consequences. Firstly, resources are consumed on inappropriate projects; Secondly, the company cannot have the advantages it may have gained if these resources had been spent on better projects (Martino JP., 1995).

In the field of project management and engineering, the selection of projects for portfolio is a popular and wide investigating research topic (Aaker and Tyebjee 1978; Bouyssou et al. 2006; Carraway and Schmidt 1991; Dickinson et al. 2001; Ewing et al. 2006; Golabi et al. 1981; Talias 2007; Fox et al. 1984; Henriksen and Palocsay 2008; Kleinmuntz and Kleinmuntz 1999; Kleinmuntz 2007; Kuei et al. 1994; Liesio et al. 2007; Stummer et al. 2009; Mavrotas et al. 2006; Medaglia et al. 2007a, 2007b; Peng et al. 2008a; Santhanam and Kyparisis 1995; Golabi 1987; Stummer et al. 2003; Liesio 2006; Cooper et al. 1999). Generally, selecting a subset of projects from a bigger set of projects which is called project portfolio, on the basis of multiple selection criteria is a typical multi-criteria decision-making (MCDM) problem in public organization (Medaglia et al. 2007b; Golabi 1987; Kleinmuntz and Kleinmuntz 1999; Kleinmuntz 2007; Ewing et al. 2006) and in industrial firms (Mavrotas et al. 2006; Golabi et al. 1981; Talias 2007; Stummer et al. 2003).

Since project portfolio selection is a very important issue in project and engineering management, a lot of studies proposed approaches (most with successful practical applications) to solve project portfolio selection problem (PPSP) (Aaker and Tyebjee 1978; Bouyssou et al. 2006; Carraway and Schmidt 1991; Dickinson et al. 2001;Fox et al. 1984; Peng et al. 2008a;Golabi et al. 1981; Talias 2007; Kleinmuntz 2007; Ewing et al. 2006; Kuei et al. 1994; Liesio 2006; Cooper et al. 1999; Liesio et al. 2007; Stummer et al. 2009; Henriksen and Palocsay 2008; Mavrotas et al. 2006; Medaglia et al. 2007a,2007b; Santhanam and Kyparisis 1995; Golabi 1987; Kleinmuntz and Kleinmuntz 1999; Stummer et al. 2003). As an example, Aaker and Tyebjee (1978) utilized a quadratic 0–1 programming method to select interdependent R&D projects. Likewise, Mavrotas et al. (2006) combined multi-criteria decision analysis (MCDA) with 0–1 integer programming (IP) for project prioritization under policy restrictions. Fox et al. (1984) presented an economic model that included benefit interactions (called present value interactions) between R&D projects and produced some promising results for project portfolio selection problem. Carraway and Schmidt (1991) proposed an improved discrete dynamic programming (DDP) algorithm to allocate resources among interdependent projects. Medaglia et al. (2007a) proposed a multi-objective evolutionary method for linearly constrained projects selection under uncertainty. Particularly, Golabi et al. (1981) proposed an additive multi-criteria value model for project portfolio selection problems. U.S. Department of Energy (DOE) utilized an integer linear programming (ILP) problem subject to resource constraints to select portfolio of solar energy projects. Similarly, Kleinmuntz and Kleinmuntz (1999) and Kleinmuntz (2007) also applied the additive model that has been presented by Golabi et al. (1981) to assist capital budgeting in over 750 hospitals and healthcare organizations in the United States. Furthermore, a three-phase approach including multi-objective integer linear programming (MOILP) has been proposed by Stummer and Heidenberger (2003) for R&D project portfolio selection and presented results of implementing a decision support system (DSS) based on this model in an industrial enterprise. likewise, Stummer et al. (2009) and Henriksen and Palocsay (2008) developed some multi-criteria DSS for evaluating and selecting different projects and obtained some interesting results about project portfolio selection. Carazo et al. (2009) solved a multi-objective project portfolio selection model. Yu et al. (2012) proposed a genetic algorithm based multi-criteria algorithm for project portfolio selection problem. Tupia et al. (2013) proposed an improved genetic algorithm for selection of IT projects with a portfolio problem approach. Nowak (2013) presented a concept of a new methodology based on interactive approach for project portfolio selection. Naderi (2013) proposed a mathematical formulation in form of mixed integer linear programming model and uses three effective metaheuristics in form of the imperialist competitive algorithm, simulated annealing and genetic algorithm are developed to solve the problem of selecting and scheduling a set of projects among available projects.