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Decision Support

A mixed R&D projects and securities portfolio selection model

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Abstract

The business environment is full of uncertainty. Allocating the wealth among various asset classes may lower the risk of overall portfolio and increase the potential for more benefit over the long term. In this paper, we propose a mixed single-stage R&D projects and multi-stage securities portfolio selection model. Specifically, we present a bi-objective mixed-integer stochastic programming model. Moreover, we use semi-absolute deviation risk functions to measure the risk of mixed asset portfolio. Based on the idea of moments approximation method via linear programming, we propose a scenario generation approach for the mixed single-stage R&D projects and multi-stage securities portfolio selection problem. The bi-objective mixed-integer stochastic programming problem can be solved by transforming it into a single objective mixed-integer stochastic programming problem. A numerical example is given to illustrate the behavior of the proposed mixed single stage R&D projects and multi-stage securities portfolio selection model.

Keywords: Portfolio selection; R&D project portfolio selection; Semi-absolute deviation risk function; Mixed-integer stochastic programming problem

1. Introduction

During the past decade there has been a dramatic increase in the institutional investment. Although most of those investments remain focused on the traditional securities investment, there is growing attention to various forms of alternative investment classes, e.g., venture capital, private equity, private debt and real estate. With the extension of investment asset classes, the overall portfolio risk can be lowered while the potential for more benefit can be increased over the long term.

The mean variance methodology for portfolio selection proposed by Markowitz [22,23] has been central to research activities in the traditional securities investment field. Following Sharpe [28], some researchers proposed a series of linear risk functions [1,20,21], e.g., Konno and Yamazaki's [16] mean absolute deviation risk

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function, Mansini and Speranza's [19] mean semi-absolute deviation risk function, Gini's mean difference risk function [31], Young's [32] minimax risk function. Recently, Lai et al. [18] formulated portfolio selection models with interval numbers. In their models, the semi-absolute deviation risk function is extended to the interval case. Fang et al. [9] studied the portfolio selection problem based on the fuzzy decision theory.

For a long-term securities investment, an investor may adjust his/her portfolio positions timely with the varying environment to obtain more profit. Many researchers have studied dynamic portfolio selection problems, e.g., Dantzig and Infranger [7], Dumas and Luciano [8], Merton [24] and Zhu et al. [34]. Dynamic portfolio selection models can be categorized into two classes, continuous time models and discrete time models. Generally, the discrete time dynamic portfolio selection problem is more amenable to mathematical programming methods. In recent years, with the development of computer hardware and software, abundant work using stochastic programming methods has been done in the study of multi-stage portfolio selection problems. Mulvey and Vladimirous [25] proposed a stochastic network model for asset allocation. Klaassen [15] gave a synthesis of financial asset-pricing theory and stochastic programming models for asset-liability management. Zenios et al. [35] studied the portfolio management for the fixed-income bond. Zhao and Ziemba [33] put forward a multi-period stochastic programming asset allocation model with transaction costs. Ji et al. [12] proposed a stochastic goal programming model for multi-stage portfolio management based on scenario analysis via moments approximation using linear programming. For a comprehensive treatment of portfolio selection and asset pricing, see the monograph by Wang and Xia [30].

In today's extremely competitive business environment, investors may consider investing their funds in other kinds of assets besides securities. Byrne and Lee [4] and Keng [14] found that the mixed asset portfolio including listed property trusts, direct property and financial assets always dominated the financial asset portfolio. Portfolio selection of research and development (R&D) projects is one of the most important decision problems which corporations should face. In recent years, some researchers studied R&D project portfolio selection problems by using mathematical programming methods, e.g., Coffin and Taylor III [6], and Ringuest et al. [27]. Some securities and R&D projects can be integrated into a mixed asset portfolio. Gustafsson et al. [10] proposed a mixed asset portfolio selection model involving projects and securities. In [10], apart from the fact that decision variables for projects are binary, the projects investment components are treated in the same way as the securities investment components. However, the properties of projects and securities investments are different. Generally, it will take much more time to execute R&D projects. During a long investment horizon, an investor may reallocate his/her securities investment at any time while he/she cannot adjust the R&D projects. Therefore, we may consider securities investment as multi-stage investment while R&D projects investment as single-stage investment in the same investment horizon. In this paper, we construct a mixed single-stage R&D projects and multi-stage securities portfolio selection model.

The paper is organized as follows. In Section 2, we present a bi-objective mixed-integer stochastic programming model for the mixed single-stage R&D projects and multi-stage securities portfolio selection problem. This model can be solved by transforming it into a single objective mixed-integer stochastic linear programming model. In Section 3, based on the idea of moments approximation [12], we give a scenario generation approach for the stochastic returns of single-stage R&D projects and multi-stage securities. In Section 4, a numerical example is given to illustrate the behavior of the proposed model and, in particular, its efficient frontier is constructed. In Section 5, we test the proposed scenario generation method. Some concluding remarks are given in Section 6.

2. Model formulation

2.1. Problem description

In this paper, we assume that an investor allocates his/her wealth among traditional securities and R&D projects. Hence, in the mixed asset portfolio selection problem, available investment asset classes are categorized into two types. The first class of assets consists of traditional securities. The second class of assets consists of R&D projects.

An R&D project is a long term process. So it will take much time to obtain profit from R&D projects. Once the investor decides to start a project, the budget of the project will be paid. The R&D project cannot be