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Fuzzy Multi-Objective Portfolio Optimization Considering Investment Return and Investment Risk

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ABSTRACT

Portfolio selection and optimization deal with the selection of the most suitable projects in a portfolio. The expected goals can be achieved while considering the balance among selected projects to ensure that all selected projects consume resources effectively. This study proposes and compares multi-objective portfolio investment optimization algorithms under uncertain conditions. The investment return (in terms of the fuzzy net present value of the portfolio) and investment risk (in terms of the credibilistic risk index) have simultaneously been considered. In addition, fuzzy chance-constrained programming is introduced as an optimization constraint to handle such uncertainty by specifying a desired confidence level of the decision makers. The outcome of this study can then help decision makers to decide what projects and when to invest. Decision makers can deal with a limited budget with logical relationships and within their desired financial and risk requirements.

KEYWORDS

Fuzzy Goal Programming Model, Fuzzy Linear Programming, Multiple Objectives, Portfolio Investment Optimization, Uncertainty, Weighted Additive Method, Zimmermann's Method

1. INTRODUCTION

Project Portfolio Management (PPM) is a set of procedures, used to assist an organization in handling a combination of projects that best fit the organization's various needs (Archer et al., 1999). To obtain efficient portfolios, investors are faced with a trade-off between a higher risk and a higher expected return by taking on more risk. As a result, the financial return, and investment risk are the most important criteria for investors to make a financial decision on investments under uncertainty. The financial problem related to project portfolio selection is how to maximize profits when distributing the available investment capital to the selected combination of projects. Investment criteria, like cash inflows and outflows and available investment capital, are regarded as definite real numbers.

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Nevertheless, these variables are perceived to be fuzzy and imprecise (in reality), and hence, account for risk in investments.

Beaujon et al. (2001) identified risk as a major problem underlying the choice of methodology for evaluating the value of a project (or a portfolio of projects). In most cases, if the value of each project is independent of the value of any other project, the major issue is to correctly identify the risk of each project in the selection of a portfolio. Furthermore, there are a number of proposed methodologies for valuing projects, including some that explicitly account for risk. According to Ghosh and Roy (2021), decision makers aimed to get a high profit with low risk as common desires, so multi-objective optimization techniques such as Fuzzy Programming (FP), Global Criteria Method (GCM), and Neutrosophic Linear Programming (NLP), were required to balance between the two desires. Yu et al. (2019) also developed a method to solve hybrid multi-attribute Multi-Attribute Decision Making (MADM) problems by applying compromise-typed functions with variable weights.

This study presents an optimal choice of portfolio investment under uncertain environments that satisfies all financial and risk constraints. The main contribution of this study is to propose an integrated multi-objective portfolio investment optimization algorithm under uncertain conditions. The proposed approach attempts to cover all aspects of such investments where financial and risk are taken into account. The financial aspect is represented by the financial return, and the risk aspect is evaluated by both the credibilistic risk index to evaluate the deviation of the result from the expected most likely outcome and the credibility index that is evaluated by the possibility to occur. Both objectives are clearly conflicting in their nature Then, due to a number of projects that are evaluated in a portfolio as well as a number of constraints and their complexity such as precedence of some projects and the pair of projects to gain synergy effect are imposed in the evaluation, this fuzzy multi objective portfolio investment optimization problem would be quite difficult to be evaluated. As a result, fuzzy goal programming and multiple objective fuzzy linear programming (i.e., Zimmermann's method and Weighted Additive Method) were introduced in this study to be a method to optimize the portfolio investment. With these approaches, the decision makers can evaluate the return and the risk of the projects simultaneously. Then, the fuzzy goal programming model and fuzzy linear programming model with a wide range of percentage deviations and weighting scenarios are used and compared to identify favorable results and their advantages. To our knowledge, applying both risk terms in the multi-objective project selection and sequencing problem and optimizing both the risk and the financial return simultaneously in the investment portfolio optimization under an uncertain environment has not been performed in the past research. Most of the past research has treated them separately or studied them in a certain environment. As a result, the essence of this study can help decision makers to evaluate and optimize their multi-objective portfolios. Decision makers can then decide what projects and when to invest under a limited budget and imposed financial and risk constraints with the optimal logical relationships under uncertainty.

The rest of this paper is organized as follows. Section 2 is a literature review that includes relevant research in the field of portfolio optimization and optimization under uncertainty. Section 3 explains the problem formulation of integrating the objective functions by minimizing the credibilistic risk index of the project portfolio while maximizing the expected financial return. In addition, Section 3 also presents an application example of project portfolio optimization. Then, Section 4 shows and compares the results. Finally, Section 5 concludes the findings and describes the limitations and suggestions for future research.

2. LITERATURE REVIEW

2.1 Portfolio Optimization

Portfolio optimization is a Project Portfolio Management (PPM) process, which deals with the coordination of multiple projects in a specific time frame to achieve strategic benefits by sharing