A New Multi-objective Model for Projects Portfolio Optimization considering Integrated Efficiency-risk Approach using NSGA-II

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Abstract: A project portfolio is a crucial decision-making process used to prepare an optimum collection of vast alternative projects. In most of the previous modeling methods, the focus is directed towards maximizing project efficiency and so, the role of risky aspects in selecting appropriate projects has been neglected. This paper presents an integrated multi-objective mathematical programming (MOMP) based on efficiency-risk for selecting a project portfolio using various techniques including data envelopment analysis (DEA), risk priority number (RPN) and non-dominated sorting genetic algorithm (NSGA-II). The proposed model can support both the capability to nominate mutually exclusive projects (conflicting projects that only one of them can be done) or any type of predecessor projects (doing a project depends on another project) and concurrent projects (need to be done at the same time) selection. Another advantage of the model is that the hyper heuristic solutions can be found in the form of several non-dominated cases and it is possible for organization's experts to choose the best and the most suitable solutions.

Keywords: Projects Portfolio Optimization; Data Envelopment Analysis (DEA); Risk Priority Number (RPN); Non-dominated Sorting Genetic Algorithm II (NSGAII)

Introduction: In the competitive world, intelligent optimum decision making is a vital task in the success of large systems. Due to lack of resources, it is not always possible to fully evaluate all proposed developmental projects. In this context, it is important to make an optimal portfolio of desired projects. The present article aimed to identify an applied methodology for the selection of project portfolios with regard to efficiency and risk assessment and the alignment of the projects' purposes with the organization's goals, while also considering the existing resource limitations and regarding risk as a main indicator. The efficiency of the projects is examined with regard to the resources used. The present paper seeks to respond to the following main questions:

- ✓ How can an optimal project portfolio be selected for an organization with maximum efficiency and minimum risk?
- ✓ Does project risk assessment in view of the two criteria of impact and probability sufficiently address the economic conditions and the complexity of the projects in the majority of research and development projects?
- ✓ What is the drawback of current risk assessment methods for project portfolios?

Responding to these questions can help organization managers select optimal project portfolios and achieve their strategic organizational objectives. Many studies have been conducted on the selection

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of project portfolios and most of them follow a qualitative and quantitative approach and use combination classification. One of the applied studies conducted on project selection is by Eilat et al., (2008), in which projects were selected within the combinational framework of DEA and a balance score card was used to select proper research and development projects (Tahri, 2015) presented two numerical methods for mathematical optimization problems for both single and multiple objectives using two values (0 and 1) as the decision variable. (Huang et al., 2016) discussed the joint problem of optimal project selection and scheduling in situations when the projects' initial outlays and net cash inflows are determined by experts' estimates due to the lack of historical data. A literature review reveals that there are a lot of optimization models available to prepare project portfolios. Most of them have one objective function to maximize project benefits or to minimize operating costs subject to operational constraints. In most modeling methods, the role of risk aspects in selecting appropriate projects has been neglected. A few of them have explored the aspect of model constraints. In other words, in the past, the main focus is directed towards economic projects while the sustainable factors (e.g., environmental and social risks) have been neglected. For this purpose, this study presents an integrated MOMP based on efficiency-risk for selecting a project portfolio using various techniques including DEA, RPN and non-dominated sorting genetic algorithm (NSGA-II).

Materials and Methods:
Step1) Preparing a list of candidate & feasible projects
Step2) Calculating efficiency of each project by using the DEA method
Step3) Calculating the risk priority number for each project
Step4) Developing a MOMP model to select the best projects
Step5) Solving the model using a Non-dominated Sorting Genetic Algorithm II (NSGAII) method

Results and Discussion: One of the main advantages of NSGAII is that the at-hand solutions can be found in the form of several non-dominated cases and therefore, it is possible for organization's experts to choose the best and the most suitable solutions. Stated differently, the expert's knowledge and viewpoints can be considered due to flexibility and availability of different solutions. Besides, it is feasible to compute the adjusted efficiency and to select the solution(s) producing the maximum efficiency as the final optimal answer(s).

Conclusion: This article used the concepts of DEA, RPN, MOMP and NSGAII modeling to propose an applied methodology for extracting an optimal portfolio of projects. In other words, we suggest the use of a Non-dominated Sorting Genetic Algorithm II as a solution method for the presented multi-objective model in order to deduce the optimal projects portfolio. By comparing the results for the proposed algorithm and existing methods, it was concluded that the previous methods can give portfolio of projects with suitable profit but these solutions face high risk and low reliability. Thus, such solutions are not acceptable by managers in organizations. The lack of attention to risk aspects leads to the non-realization of the estimated profit due to high probability of risk. Therefore, the valuable resources will be wasted. Whereas, by adjusting profit with the risk numbers, it is indicated that the profit gained by our method is so better and higher than previous methods after risk. This can indicate novelty, applicability, and performance of our method.

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