Computers & Industrial Engineering 66 (2013) 1061–1069

Contents lists available at ScienceDirect

Computers & Industrial Engineering

journal homepage: www.elsevier.com/locate/caie

Applying fuzzy multi-objective linear programming to project management decisions with the interactive two-phase method

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ARTICLE INFO

Article history:
Received 13 March 2013
Received in revised form 20 July 2013
Accepted 14 August 2013
Available online 27 August 2013

Keywords:
Project management
Possibilistic programming approach
Two-phase approach
Fuzzy multi-objective linear programming

ABSTRACT

The aim of this paper is to develop an interactive two-phase method that can help the Project Manager (PM) with solving the fuzzy multi-objective decision problems. Therefore, in this paper, we first revisit the related papers and focus on how to develop an interactive two-phase method. Next, we establish to consider the imprecise nature of the data by fulfilling the possibilistic programming model, and we also assume that each objective work has a fuzzy goal. Finally, for reaching our objective, the detailed numerical example is presented to illustrate the feasibility of applying the proposed approach to PM decision problems at the end of this paper. Results show that our model can be applied as an effective tool. Furthermore, we believe that this approach can be applied to solve other multi-objective decision making problems.

1. Introduction

In recent years, the project managers have faced the competitive environment such as the product's life cycle is becoming short and customers want more-customized services. It means when the project managers face the complicated situations, it is difficult for them to use resources and take decisions in a perfect way. With today's projects, much of the uncertainty surrounding information management simply can't be eliminated. In this case, we apply the fuzziness to improve the chances of success in project management. In addition, the degree of fuzziness not only deals with the lack of information but also supports the project managers that can make the wrong decisions in lower possibility. In another word, the experiences of the project managers on the project appropriate application reduces errors due to poor decisions may lead to opportunities for project failure.

Recently, both practitioners and academicians have been more interested in considering the issues of the relationship between project management decisions and possible problems. Numerous mathematical programming techniques and heuristics for considering the fuzzy theory have been developed for solving PM problems, each with its own advantages and disadvantages. Okuhara, Shibata, and Ishii (2007) utilized the genetic algorithm to the adaptive assignment of worker and workload control in PM decision problems. After that, Lin (2008) utilized statistical confidence-interval estimates and level $(1-\alpha)$ fuzzy numbers to solve project time–cost tradeoff problems. Arikan and Güngör (2001) utilized fuzzy goal programming (FGP) approach to solve PM decision problems with two objectives—minimizing both completion time and crashing cost. After that, Wang and Fu's work (1998) applied fuzzy mathematical programming to solve PM decision problems. The aim of these models was to minimize complete project cost and whole crashing cost simultaneously. In addition, Wang, Liang, Li and other scholars have developed and researched an interactive multiple fuzzy goal programming (MFGP) model to solve PM decision problems in a fuzzy environment. It aimed to minimize total costs, whole completion time, and complete crashing costs simultaneously (Li, Huang, & Xiao, 2008; Liu, Liang, Yeh, & Chen, 2009; Lv et al., 2010; Suo, Li, & Huang, 2012; Wang & Fu, 1998; Wang & Liang, 2004).

According to some related studies, the decision-making process is closer to the possibilistic than probability. Besides, Zadeh (1978) presented the theory of possibility, which was related to the theory of fuzzy sets by defining the concept of a possibility distribution as a fuzzy restriction. It acts as an elastic constraint on the values that can be assigned to a variable. Since the expression of a possibility distribution could be viewed as a fuzzy set, possibility distribution might be manipulated by the combination rules of fuzzy sets and

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http://dx.doi.org/10.1016/j.cie.2013.08.009

more particular about fuzzy restrictions. Buckley (1988) formulated a mathematical programming problem in which all parameters might be fuzzy variables by their possible distribution, and moreover, illustrated this problem using the possibilistic linear programming (PLP) approach. After that, Liang (2009) formulated a possibilistic programming (PLP) model to solve fuzzy multi-objective PM problems with imprecise objectives and constraints. Some related works such as Inuiguchi and Sakawa (1996), Hussein (1998) and Tanaka and Guo (2000) applied possibilistic programming linear method to address the decision-maker problems. In addition, some researchers extended the related research scope such as Kwong, Chen, Chan, and Wong (2008) proposed a hybrid fuzzy least-squares regression (HFLSR) approach to modeling manufacturing processes which features the capability of dealing with the two types of uncertainty and addresses the consideration of replication of responses in experiments. After that, Kwong, Chen, Chan, and Luo (2010) addressed a generalized FLSR approach to modeling relationships in QFD is described that can be used to develop models of the relationships based on fuzzy observations and/or crisp observations. And, Chan, Kwong, and Hu (2012) proposed a new methodology to perform market segmentation based on consumers' customer requirements with fuzziness consideration.

Besides, we found some inadequacies based on above-mentioned literatures:

1. The PLP approach for an optimization problem with fuzzy parameters is possibilistic, which lead to the increase of the number of objectives function and constraints of the model. In addition, the computing efficiency of the solutions obtained by the max–minimum operators has not been considered. Since the results obtained by the max–minimum operator cannot be compensated by other members. As a result, the efficiency of the optimal solution yielded by the minimum-max operators can be improved as it obtains multiple ideal solutions. 2. Different membership functions are formulated from decision-maker preferences and experiences, but the decision-makers have the difficulties in making tradeoffs between the alternatives because of their inexperience and incomplete information.

Although several methods have been proposed to treat this problem in above, the two-phase approach has the value described as: if the decision maker is seeking an efficient solution which can ameliorate the max–minimum operators' solution so that each membership degree should be ameliorated, then the two-phase method automatically obtains this desire if there is room for improvement (Guu & Wu, 1999).

Finally, in this paper, we consider the imprecise nature of the input data by implementing the interactive two-phase operators; and we also assume that each objective function has a fuzzy goal. The result can be obtained by determining the suitable membership function and seek an efficient solution.

2. Project management in fuzzy environment

The fuzziness comes from incomplete information and uncertainty. For example, to execute a project, the project manager will consider how to lead, how to organize, how the employer, how to plan and control the process of thinking in which ideas will be generated with incomplete and uncertainty. In addition, the higher incomplete and uncertain information is controlled; the least degree of fuzziness of the message becomes. Therefore, if the project managers have more complete and usage information, they can reduce the degree of fuzziness.

2.1. Notations and assumptions

Assume that a project has n interrelated activities that must be executed in a certain order before the entire task can be completed in the fuzzy environment. In general, environmental coefficients and related parameters are incomplete and/or vague about the planning horizon. Therefore, the incremental crashing cost for all activities, variable indirect cost per unit time, specified project completion time, and total budget is imprecise or/and fuzzy.

This problem focuses on the development of the multiple objective possibilistic linear programming (MOPLP) model to the optimum duration of each activity in the project, given a specified project completion time, the crash time tolerance for each activity and allocated total budget, and the optimal solution obtained by two-phase operator approach.

Aims of this PM decision are to minimize simultaneously whole project cost, total crashing cost and total completion time. The original multi-objective linear programming (MOLP) model proposed in this work is based on the following assumptions:

1. All the objective functions and constraints are linear.
2. Direct costs increase linearly as the duration of an activity is reduced from its normal value to its crash value.
3. The common time and the shortest possible time for each activity and the cost of completing the activity in the regular time and crash time are certain to the planning horizon.
4. Indirect cost can be divided into two categories, i.e., fixed cost and variable cost, and the variable cost per unit time is the same regardless of project completion time.
5. The decision-makers adopted the pattern of triangular possibility distribution to represent the estimated objectives and related imprecise numbers.
6. Two-phase operator is used to aggregate all fuzzy sets.

Assumptions 1, 2 and 3 imply that both the linearity and certainty properties must be technically satisfied in order to represent an optimization problem as a LP problem. For the sake of model facilitation, Assumption 4 represents that the indirect costs can be divided into fixed costs and variable costs. Fixed cost represents the indirect cost under regular condition and remains constant regardless of project duration. Meanwhile, variable cost, which is used to measure savings or increases in variable indirect cost, varies directly with the difference between actual completion and normal duration of the project. Assumption 4 concerns the simplicity and flexibility of the model formulation and the fuzzy arithmetic operations. Assumption 5 addresses the effectiveness of applying triangular possibility distribution to represent imprecise objectives and related imprecise numbers. In general, the project managers are familiar with estimating optimistic, pessimistic and most likely parameters from the use of the Beta distributions specified by the class PERT. The pattern of triangular distribution is commonly adopted due to ease in defining the maximum and minimum limit of deviation of the fuzzy number of its central value. Assumptions 5 and 6 convert the original MOLP problem into an equivalent ordinary single-objective LP form that can be solved efficiently by the standard simplex method.