Chapter 6
Bi-Level Programming for Earning Management in Imprecise and Random Environments

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ABSTRACT

Organizations striving in today's environment of active technological and business transformations are confronted with the difficulties of "twofoldness," that is, performing efficiently in the present while innovating effectively for the future. Administrators inside these organizations not only have to concentrate on the business benefit and profitability of each of their authorized commodities and services but must also guarantee their ability to introduce into next-generation contributions that output properties that will maintain and even enhance their renewed global competitiveness. The surprisingly fast breakdown of so many probably great companies over the last decade gives an extensive declaration to the consequence of accomplishing this dualism. In this chapter, to deal with this dualism, the authors consider a fuzzy stochastic bi-level programming problem in the mathematical models. The fuzziness and randomness concept has been taken care of by the fuzzy random variable as the parameter of the bi-level programming problem. A two-stage approach has been defined to solve the problem.

1. INTRODUCTION

In a hierarchical organizational structure, decision-makers frequently trade with conflicting goals. At one level of the hierarchy, a DM may hold his individual goal and decision area and due to another level of the hierarchy, it may be affected by the distinct levels. The hierarchical organization trades with decentralized programming problems with various decision-makers which can be referred to as multi-level programming (MLP). The bi-level programming problem (BLPP) is a specific instance of MLP. There are

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two separate hierarchical levels including a couple of decision-makers in BLPP. Both the DM examines their variables individually. The upper-level decision-maker is called the leader who can influence the objective function of the lower level (Decision-maker of the lower level is called the follower). Both the DM wants to optimize its objective function and is influenced by the judgments of one another. The nested structure of the overall problem requires that a solution to the upper-level problem may be feasible only if it is an optimal solution to the lower level problem. Bi-level programming is complicated to deal with due to its inherent non-convexity. The principal component of analysis on the bi-level programming problem is yet concerned in the deterministic case. In the literature, Bi-level programming problem has been first formulated by Candler and Townsley (1982) and *Fortuny & McCarl (1981)*.

The BLPP models defined by *Candler and Townsley (1982)*, *Bialas and Karwan (1984)*, and *Bard (1991)*can be formulated as:

$$\max_{X} G_1\left(X,Y\right) = AX + BY$$

where Y solves

$$\max_{Y} G_2\left(X,Y\right) = CX + DY$$

s.t. $EX + FY \leq R$,

Here $A, C \in \mathbb{R}^{n_1}$, $B, D \in \mathbb{R}^{n_2}$, $R \in \mathbb{R}^m$, E is an $m \times n_1$ matrix, F is an $m \times n_2$ matrix. $\left(X,Y\right) \in \mathbb{R}^n$ is a vector of decision variables which can be controlled by the decision makers. $X \in \mathbb{R}^{n_1}$ is a vector control by leader and $Y \in \mathbb{R}^{n_2}$ by follower, where $n_1 + n_2 = n$. G_1 & G_2 are the objectives functions of leader and follower respectively. In the past several approaches have been studied by *Bard (1984)*, *Bard(1991)*, *Wen and Hsu (1991)*, *Wen and Hsu (1991)*, *Bialas and Karwan (1984)* and others to solve the bi-level programming problem.

Bi-level programming problems are usually encountered in the field of economics, transportation, environmental economics, decision science, engineering, business, etc. Yet, in real-world circumstances, chance and impreciseness are included in describing the parameters. It is challenging to establish parameters in the objective functions and constraints in this case. Both the DMs have to take a decisiveness even if they do not comprehend the parameter of the problem with complete conviction hence bi-level programming problem with fuzzy parameter and Stochastic bi-level programming problem (bi-level programming with random variable coefficients) has been developed separately. *Sakawa et. al. (2000)* described the bi-level programming problem with fuzzy parameter and introduced a fuzzy programming method to solve it. *Zhang and Lu (2005)* designed a fuzzy number based Kuhn-Tucker condition to solve bi-level programming problem with the fuzzy parameter. Some multi-objective bi-level programming also has been studied with fuzzy parameter *Gao et. al. (2009)* and *Zhang and Lu (2010)*. For the randomness, *Nishizaki et. al. (2003)* solved the bi-level programming problem with random variable coefficients. They considered the variance of the objective function of the leader and means of the objective function of the follower to find the deterministic programming problem. Stochastic bi-level programming problem has been solved by Kosuch et. al. with probabilistic knapsack constraints, which can be used to jointly