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LINEAR PROGRAMMING AND ITS APPLICATIONS

Eiselt, H. A., & Sandblom, C.-L. (2007). Berlin Heidelberg: Springer-Verlag, ISBN 978-3-540-73670-7, XI+380

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In everyday life, as in many scientific fields, there is often a need for finding an optimal (minimum or maximum) solution to a problem, where certain conditions are met. Due to the simplex method, linear programming is one of the most effective approaches to formulating and solving complex problems of decision making. It is therefore increasingly applied in modern society in the planning of economic development and the control of various activities that are limited in the amount of available resources (labor force, materials, a budget, time, etc.).

The book entitled: *Linear Programming and its Applications* (2007), by H. A. Eiselt and C.-L. Sandblom, presents a unique approach to the problem of linear programming, which aims to place an emphasis on models and applications without omitting mathematical accuracy and correctness. Accordingly, the process of solving a problem is illustrated, from setting the model to analyzing the optimal values. The authors' approach, the type and the selection of different applications as well as their limitation to a small number of sub-themes in the field (which is actually one of its advantages) suggest that the book is primarily intended for advanced students and researchers engaged in operations research and their application to economic problems.

H. A. Eiselt and C.-L. Sandblom note that the book is the last part of the trilogy. The previous two volumes are *Integer Programming and Network Models* (2000) and *Decision Analysis, Location Models, and Scheduling Problems* (2004). Although the order which the books were published in is not entirely clear, all the three volumes are similar in style, emphasize models, applications, formulations/reformulations and provide the numerical examples of the described algorithms.

The book begins with the two (A and B) introductory chapters describing the mathematical apparatus necessary for understanding the continuation of the book. Chapter A (pp. 1-30) provides a clear and concise introduction to linear algebra and highlights concepts important for the field of linear programming. Complicated mathematical proofs are excluded in order to maintain conciseness in interpretation, and readers interested in a deeper analysis are referred to the appropriate literature. Chapter B (pp. 31-44)

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presents a brief account of computational complexity, providing the reader with minimum – however quite enough – knowledge in this field that a book devoted to optimization should offer. Although readers with little prior knowledge in mathematics are unlikely to fully understand the topic briefly described and not so simple, that was not a goal pursued by the authors.

Chapter 1 (pp. 45-66) provides an introduction to the non-classical optimization method known as mathematical programming, which also includes linear programming. The relationship between mathematical programming and modeling is specifically described, for the purpose of presenting an example from real life situations with appropriate variables and parameters using mathematical model. Section 1.5, entitled: *Solving the Model and Interpreting the Printout*, illustrates the theory described with the specific examples. Chapter 2 (pp. 67-128) contains a good selection of the optimization problems pointing to important skills in modeling, noting the difference between a theoretically optimal and practical solution in optimization. The authors clearly describe the mathematical models of the objective function, a set of constraints and the conditions of non-negativity, which are actually the three essential parts of the linear program. Chapter 3 (pp. 129-166) is entirely devoted to the simplex method for solving linear programming problems. The graphical method is first described in two parts and subsequently the algebraic method is described as well. Wherever appropriate, graphic illustrations enhance the effect of the algebraic results. In Chapter 4 (pp. 167-202), there is a formal description of the theory of duality in the first place, only to be followed, for the ease of understanding, by the exemplified demonstration of the relationship between a primal and a dual problem. Because of the principally rigorous theoretical approach, readers with less prior knowledge in mathematics will have more difficulties to understand this chapter than the previous ones. As the dual problem has its own clear and important economic significance, except for calculating the solution of the primal one, the last part of this chapter is devoted to the economic interpretation of duality. Chapter 5 (pp. 203-224) is an upgrading of Chapter 3 in terms of adding the revised simplex method. It describes the method for introducing the upper bound of constraints and for the generating of the columns of variables when necessary. The chapter contains several examples of the dual-simplex method with a brief and clear explanation. In general, this chapter provides a reader with the main reasons for a possible modification of the simplex method, but does not present enough information necessary for the pursuance of the idea.

Chapter 6 (pp. 225-260) focuses on the post-optimal analysis through the formal presentation of the sensitivity of the optimal solution to changes in initial assumptions. Using a graphical analysis, the consequences of the changes in the free parameters, the objective function coefficients, the adding/deleting of the variables or constraints are described, and generally, the answer to the question: "What if..." is given. The last part explains the economic analysis of optimal solutions with a good numerical example.

Chapter 7 (pp. 261-294) describes alternative non-simplex methods for solving linear programming problems. This part is concise and mainly focused on the interior point method, with a reference to the other methods such as: the traversal method, the external pivoting method, the gravitational method, the bounce and ellipsoid method. The chapter could be expanded with a reference to the relevant literature analyzing the application of these methods in practice. (I also believe it would be good to critically analyze the interior point method, which has increasingly been used in practice in recent decades, and to compare it with the simplex method.)

Chapter 8 (pp. 295-324) describes the techniques important for solving the problems that do not fit in the "standard" model of linear programming. This is a very useful chapter because the reader is referred to the methods of overcoming difficulties in the modeling of the given optimization problem. The method of reformulating a problem in the general form of a linear programming problem is demonstrated (by replacing variables, conditions, and objective functions). Although the chapter covers the basics of the field, readers can expect to come across interesting and useful illustrative examples.

Chapter 9 (pp. 325-362), the last one, as a good complement to the rest of the book, gives an introduction to the problem of multi-objective programming. The concept of the vector versus scalar optimization is well explained. It also describes the established methods for solving multi-objective programming, such as: the *weighting method, constraint, reference point programming, fuzzy programming, goal programming and bilevel programming.* Some of these methods are widely used in economics, which is shown on concrete examples.

In their introduction, H. A. Eiselt and C.-L. Sandblom clearly indicate their desire to ensure the "longevity" of the book by paying more attention to analyzing the essence of the problem and to describing the appropriate models; however, the book lacks the use of a software package for solving optimization problems. Thus, it would be easier for researchers with insufficient experience in the field of linear programming to identify a high potential of the applications of the field in practice. However, since it is obviously impossible to introduce the whole mathematical apparatus used in linear programming in just one book, the authors have rightly focused on what is mathematically the most basic and economically the most important. Readers who study the book carefully will be able to understand the majority of scientific and professional articles in journals dedicated to this topic.

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