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Fuzzy Engineering Economics with Applications

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Preface

Fuzzy set approaches are suitable to use when the modeling of human knowledge is necessary and when human evaluations are needed. Fuzzy set theory is recognized as an important problem modeling and solution technique. It has been studied extensively over the past 40 years. Most of the early interest in fuzzy set theory pertained to representing uncertainty in human cognitive processes. Fuzzy set theory is now applied to problems in engineering, business, medical and related health sciences, and the natural sciences. This book handles the fuzzy cases of classical engineering economics topics. It contains 15 original research and application chapters including different topics of fuzzy engineering economics.

When no probabilities are available for states of nature, decisions are given under uncertainty. Fuzzy sets are a good tool for the operation research analyst facing uncertainty and subjectivity. The main purpose of the first chapter is to present the role and importance of fuzzy sets in the economic decision making problem with the literature review of the most recent advances.

The second chapter includes two subchapters on fuzzy net present value analysis written by different authors and different points of view. The first subchapter presents arithmetic Operations over Independent Fuzzy Numbers and Economic Concepts Review. Then, it gives the techniques for Comparing and Ordering Fuzzy Numbers of Independent numbers and dependent numbers. It examines fuzzy case with Partial Correlation. The chapter also includes many numerical applications. The second subchapter introduces fuzzy net present value analysis. The present value approach is first analyzed by crisp values. After the basic definitions of fuzzy numbers are given, the Concept And Applications of fuzzy Present Value are handled. The other components of this chapter is the fuzzy and probabilistic approach to the present value, the fuzzy net present value maximization as an objective in project selection problems, applications to the valuation of projects with future options, interpretation of fuzzy present value and fuzzy net present value, fuzzy net present value as an objective in optimization problems from the industry, fuzzy net present value as an objective in spatial games, and fuzzy classification based on net present value.

Chapter 3 includes two subchapters on fuzzy equivalent annual worth analysis. Equivalent annual worth analysis is one of the most used analysis techniques for the evaluation of investments. The main process is to convert any cash flow to an equivalent uniform cash flow. Later, the decision is given taking the economic category of

the problem into account. In the first subchapter, it is shown how you can apply this technique when the parameters are all fuzzy. Numerical examples are given for different analysis periods. In the second subchapter, some case studies are presented using fuzzy equivalent uniform annual worth analysis. It includes three case studies and each case is studied for both crisp and fuzzy cases. Trapezoidal fuzzy numbers and correlated, uncorrelated, and partially correlated cash flows are handled in the cases.

Chapter 4 is on fuzzy rate of return analysis and includes two subsections. The definition of the fuzzy internal rate of return is not unequivocal and requires some discussion. In the first subchapter, crisp rate of return analysis is first introduced. Then fuzzy rate of return analysis is handled. The problem of defining fuzzy internal rate of return together with certain applications is discussed. In the second subchapter, the problem of *IRR* estimation in fuzzy setting is considered in the framework of more general problem of fuzzy equations solving. The concept of restricted fuzzy *IRR* as the solution of the corresponding non-linear fuzzy equation is proposed and analyzed.

Benefit-cost analysis is a systematic evaluation of the economic advantages (benefits) and disadvantages (costs) of a set of investment alternatives. The objective of a benefit-cost analysis is to translate the effects of an investment into monetary terms and to account for the fact that benefits generally accrue over a long period of time while capital costs are incurred primarily in the initial years. In the next chapter, benefit cost ratio (BCR) analysis is analyzed under fuzzy environment. Fuzzy continuous payments and fuzzy discrete payments are summarized briefly.

In an uncertain economic decision environment, our knowledge about the defender's remaining life and its cash flow information usually consist of a lot of vagueness. To describe a planning horizon which may be implicitly forecasted from past incomplete information, a linguistic description like `approximately between 8 and 10 years' is often used. In Chapter 6, using fuzzy equivalent uniform annual cash flow analysis, a fuzzy replacement analysis for two operating systems is handled.

Depreciation is an income tax deduction that allows a taxpayer to recover the cost of property or assets placed in service. The seventh chapter includes the fuzzy after-tax cash flow analyses in case of fuzzy cash flows, fuzzy depreciation, fuzzy tax rate, and fuzzy minimum attractive rate of return with numerical examples.

The eighth chapter presents the ways of incorporating the parameter fuzzy inflation to the engineering economy analyses. Inflation is a financial parameter difficult to estimate. The fuzzy set theory gives us the possibility of converting linguistic expressions about inflation estimates to numerical values. In this chapter, discounted cash flow techniques including these fuzzy expressions are given. The obtained results show the interval of the worst and the best possible outcomes when fuzzy inflation rates are taken into account.

Sensitivity analysis is performed in case of uncertainty. In the ninth chapter, the authors are concerned with the concept, properties and algorithms of differentiation of the Choquet integral. The differentiation of the Choquet integral of a nonnegative measurable function is studied in the setting of sensitivity analysis. The differentiation of the Choquet integral is extended to the differentiation of the generalized t-conorm integral. The Choquet integral is applied to the credit risk analysis (long-term debt rating) to make clear the significance of them.

Techniques for ranking simple fuzzy numbers are abundant in the literature. However, there is a lack of efficient methods for comparing complex fuzzy numbers that

are generated by fuzzy engineering economic analyses. In the next chapter a probabilistic approach is taken instead of the usual fuzzy set manipulations. The Mellin transform is introduced to compute the mean and the variance of a complex fuzzy number. The fuzzy number with the higher mean is to be ranked higher. Two fuzzy cash flow analyses and a fuzzy multiple attribute decision analysis are illustrated in order to demonstrate the suitability of the probabilistic approach.

A decision tree is a method you can use to help make good choices, especially decisions that involve high costs and risks. Decision trees use a graphic approach to compare competing alternatives and assign values to those alternatives by combining uncertainties, costs, and payoffs into specific numerical values. A fuzzy decision tree is a generalization of the crisp case. Fuzzy decision trees are helpful for representing ill-defined structures in decision analysis. Chapter 11 presents investment analyses using fuzzy decision trees with examples.

Chapter 12 includes two subchapters on fuzzy multiple objective evaluation of investments. The first subchapter analyzes the methods for Multiobjective Decision Making in the fuzzy setting in context of Investment Evaluation Problem. The problems typical for Multiobjective Decision Making are indicated and new solutions of them are proposed. The problem of appropriate common scale for representation of objective and subjective criteria is solved using the simple subsethood measure based on α -cut representation of fuzzy values. To elaborate an appropriate method for aggregation of aggregating modes, the authors use the synthesis of the tools of Type 2 and Level 2 Fuzzy Sets. The second subchapter proposes the use of fuzzy data mining process to support the analysis processes in order to discover useful properties that can help to improve investment decisions. The stock market analysis is a high demanded task to support investment decisions. The quality of those decisions is the key point in order to obtain profits and obtain new customers and keep old ones. The analysis of stock markets is high complex due to the amount of data analyzed and to the nature of those.

Chapter 13 presents two main results that are accomplished in the fields of financial management and strategic investment planning. Applying the obtained theoretical results, the authors discuss the development of two soft decision support models in detail, which use possibility distributions to describe and characterize the uncertainty about future payoffs.

Pricing of options, forwards or futures often requires using uncertain values of parameters in the model. For example future interest rates are usually uncertain. In Chapter 14, the authors use fuzzy numbers for these uncertain parameters to account for this uncertainty. When some of the parameters in the model are fuzzy, the price then also becomes fuzzy. The authors first discuss options: (1) the discrete binomial method; and then (2) the Black-Scholes model. Then they look at pricing futures and forwards.

Addressing uncertainty in Lorie-Savage and Weingartner capital rationing models is considered in the literature with different approaches. Stochastic and robust approach to Weingartner capital rationing problem are examples of non-fuzzy approaches. In Chapter 15, the authors provide examples of fuzzy approach to Lorie-Savage problem, and illustrate the models with numerical examples. The solution of the generic models requires evolutionary algorithms; however for the models with triangular or trapezoidal fuzzy numbers, branch-and-bound method is suggested to be sufficient.

The last chapter presents future directions in engineering economics. It has also some recommendations for the content of the engineering economics books in the future.

I hope that this book would provide a useful resource of ideas, techniques, and methods for present and further research in the applications of fuzzy sets in engineering economics. I am grateful to the referees whose valuable and highly appreciated works contributed to select the high quality chapters published in this book. I am also grateful to my research assistant, Dr. Ihsan Kaya, for his helps in editing this book.

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Contents