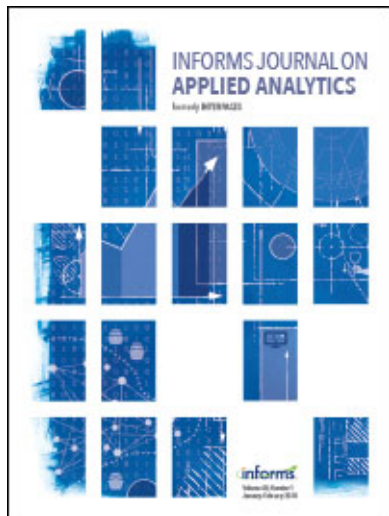




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Book Reviews

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 Book Reviews

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In *Book Reviews*, we review an extensive and diverse range of books. They cover theory and applications in operations research, statistics, management science, econometrics, mathematics, computers, and information systems. In addition, we include books in other fields that emphasize technical applications. The editor will be pleased to receive an email from those willing to review a book, with an indication of specific areas of interest. If you are aware of a specific book that you would like to review, or that you think should be reviewed, please contact the editor.

The following books are reviewed in this issue of *Interfaces*, 45(6), November–December 2015: *Stochastic Optimization Methods: Applications in Engineering and Operations Research*, Kurt Mardi; *The Climate Casino: Risk, Uncertainty, and Economics for a Warming World*, William D. Nordhaus.

MARTI, KURT. 2015. *Stochastic Optimization Methods: Applications in Engineering and Operations Research, Third Edition*. Springer-Verlag. 368 pp. \$179.00.

The contents of the third edition of this book differ from those of the first and second (Marti 2008) editions, which are almost coincident, except for one chapter. Stochastic optimization methods aim to solve optimization problems, the mathematical models of which include uncertain parameters modeled by random variables. To define this subject, the author uses the terms stochastic programming (Kall and Wallace 1997) and stochastic optimization (Schneider and Kirpatrik 2006). The methods attributed to stochastic programming are frequently a generalization of the methods of mathematical programming for stochastic optimization problems. The term stochastic optimization generally describes a broader field of research, such as global optimization methods, which are based on stochastic models of the type that Calvin and Zilinskas (2005) discuss; Zhigljavsky and Zilinskas (2008) consider these methods as a constituent of stochastic (global) optimization. Schneider and Kirpatrik (2006) also consider the randomized search methods supposed for deterministic problems as constituents of stochastic optimization. Based on Mardi's use of stochastic optimization in the book's title, we know that he assumes the reader is sufficiently knowledgeable about probability theory, but does not necessarily have a deep

knowledge of mathematical programming. The subtitle suggests that the book focuses on applications; to be more precise, it focuses on the applications in engineering and operations research. Indeed, the problems considered originate in practice; however, this book considers their mathematical aspects, and the readers who will derive the most benefit from this are experts in applied mathematics.

The book has eight chapters. In the first chapter, Mardi introduces the basic concepts of stochastic optimization, and explains the principle of constructing stochastic optimization methods by transforming original stochastic problems into appropriate deterministic analogues. In the next four chapters, he considers the problems of optimal stochastic control. The sixth and seventh chapters discuss the optimal design of mechanical construction, and the last chapter addresses the robustness and stability properties of the solutions of stochastic optimization problems using the methods of statistics, and of information and optimal decision theories.

Optimal control problems arise in various engineering and business applications. Although efficient methods for solving deterministic problems have been developed using the Pontryagin maximum principle and dynamic programming, these theoretical principles cannot always be applied in the implementation of efficient algorithms for stochastic optimal-control problems. Therefore, the author develops

specific methods for the problems that are important from the perspective of applications. In Chapter 2, he formulates the problems of optimal control under stochastic uncertainty, and introduces notation and the basic concepts, including the objective function, open-loop and closed-loop feedback controls, and stochastic Hamiltonian. In Chapter 3, he proposes an algorithm for stochastic optimal open-loop feedback control; the solution is derived by combining analytical methods with the approximate solution of a two-point boundary-value problem. He illustrates the performance of the proposed algorithm using an example of control of a supplementary active system, where the expected cost for the control and the terminal cost should be minimized. Chapter 4 presents a method for planning trajectories and controlling robots; the robots are described by a system of second-order differential equations and controlled by the offline open-loop method, which involves stochastic optimization and statistical estimation of unknown parameters. Mathematicians will understand that the many formulas and several theorems used for substantiation mean that the proposed method is robust, and the stable feedforward and feedback controls can be defined with potential reductions in online correction expenses. In Chapter 5, methods described for the optimal design of regulators focus on the cases in which observation errors and uncertain parameters are modeled by random variables. Such an approach is more flexible and frequently more appropriate than the minimax approach, which is pessimistically oriented to worst-case conditions; however, a stochastic optimal design can be difficult to apply because of the complexity of computing the conditional probability distributions of unknown parameters, which constitute the major part of computing the objective function. Mardi presents a method to overcome these difficulties for an optimal design of a proportional-integral-derivative (PID) regulator.

Chapter 6 considers the optimization of mechanical structures with random parameters. The problem of optimal design of a plane frame is reduced to a large-scale two-stage stochastic linear optimization problem with a complete fixed recourse. The objective function represents the collapse-load factor, and the constraints include the equilibrium equation of a statically indeterminate loaded structure in addition to the interval

constraints for internal forces and bending moments. To evaluate the violation of the yield, strength, and safety conditions, various linearizations are applied. The proposed method reduces the problem of stochastic optimization to a form suitable for applying large-scale linear programming solvers. In Chapter 7, Mardi presents a method to optimize mechanical structures for plastic design; it is largely a method for stochastic structural optimization with a quadratic-loss function. Based on the mechanical survival condition of plasticity theory, he defines a quadratic-loss criterion. The definition of linear constraints, incorporating factors such as linearized yield and strength conditions and linear equilibrium equations, completes the construction of a quadratic programming problem. He substitutes this problem for the original problem of minimization of expected costs subject to the expected-recourse-cost constraint. The method proposed is also applicable to similar problems of plastic design; two examples illustrate this method.

The last chapter addresses the methods used to estimate the distributions of random variables, which are included in models of the considered stochastic optimization problems. The author applies the methods of information and decision theories to find the appropriate theoretical distributions, and estimates the parameters using known statistical methods. The estimation errors result in errors in determining the optimal solution for the original problem. An optimal estimation method should balance losses caused by incorrect decisions made in solving the original problem, and losses caused by estimating the incorporated stochastic model: by increasing the estimation precision (for the increased estimation costs), errors in the solution of the original problem (measured by the costs of deviation from the optimal solution) can be reduced. In addition, stability properties of the proposed method are studied.

The considered book presents a mathematical analysis of the stochastic models of important applied optimization problems. Mardi presents detailed methods to solve these problems, rigorously proves their properties, and uses examples to illustrate the proposed methods. This book would be particularly beneficial to mathematicians working in the field of stochastic control and mechanical design.

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NORDHAUS, WILLIAM D. 2013. *The Climate Casino: Risk, Uncertainty, and Economics for a Warming World*. Yale University Press. 392 pp. \$30.00.

Climate change (global warming) is one of the most salient problems confronting humankind today, and William Nordhaus is one of the economics profession's most esteemed researchers on the economics of climate change. Over the past three decades, primarily through his work with integrated assessment models such as the dynamic integrated climate-economy (DICE) model, Nordhaus has had a significant influence on our contemporary understanding of the economic aspects of climate change and on approaches we might use to address this seemingly intractable problem. In *The Climate Casino: Risk, Uncertainty, and Economics for a Warming World*, Nordhaus provides us with a lucid, multidisciplinary discussion of the problem of climate change. Although this book builds on much of his previous research, its basic objective is to comprehensively survey the fields of climate change science and economics.

Using the language of economics, Nordhaus begins by pointing out that “global warming is the Goliath of all externalities because it involves so many activities; it affects the entire planet; it does so for decades and even centuries; and, most of all, because none of us acting individually can do anything to slow the changes” (p. 18). Because climate change is a multifaceted problem, we are told that good models are a useful tool for comprehending the key underlying issues, because good models “capture the essence of the process without overwhelming the user with unnecessary clutter” (p. 25).

What effects might the climate change problem have on human and other living systems? Nordhaus exhaustively studies this question. He explains correctly that agriculture, human health, and the oceans will all be affected. In addition, we can expect wildlife and species loss and the intensification of hurricanes. In this regard, he gives readers four key messages. First, climate change impacts are generally difficult to estimate. Second, relative to the likely overall changes in aggregate economic activity, “the economic impacts from climate change will be small . . .” (p. 144). Third, the most deleterious impacts from climate change will occur outside the market and in what Nordhaus calls “unmanaged and unmanageable human and natural systems . . .” (p. 145). Finally, to determine whether policies designed to address climate change are aiming too high or too low, we must “consider the costs of slowing climate change and of attaining different targets . . .” (p. 146).

Climate change can be decelerated using two broad classes of strategies, which Nordhaus refers to as adaptation and mitigation strategies. A key point emanating from his discussion is that if we are to effectively deal with climate change, virtually all nations must participate and collectively attack the problem. Having said this, he goes on to explain the notion of discounting and the fundamental role that the discount rate has in decision making over time. He explains the difference between the so-called descriptive and prescriptive approaches to discounting, and notes that he adopts the descriptive approach “because it reflects the reality that capital is scarce, that societies have valuable alternative investments and that climate investments should compete with investments in other areas” (p. 188).

Although his discussion of these strategies is valuable, this part of the book would have profited from a more elaborate discussion of three points. First, given that the entire exercise of cost-benefit analysis is prescriptive in nature, should the prescriptive approach also be applied? Second, what difficulties does traditional cost-benefit analysis face when this analysis is being conducted under uncertainty? The recent research concerning the so-called dismal theorem by Martin Weitzman of Harvard University is germane to this point. Third, how is cost-benefit analysis affected by the knowledge that mitigation costs

are known and generally reversible, but the damages from climate change are typically unknown?

The book concludes with engaging discussions of policies for slowing climate change, relevant institutions, and the politics of climate change. Pointing to the central role of carbon prices in reducing carbon emissions, Norhaus tells us that such prices are salient because “they affect all aspects of the economy from production to innovation; and they economize on the information that people need to make efficient decisions” (p. 227). With regard to politics, the author provides a polite but cogent critique of the position of contrarians—those who believe that climate change is

not a problem and that if it is, then natural forces alone are responsible for this problem.

In summary, although this book has some errors of omission, I would be remiss in my duties if I did not state unequivocally that it is a fine book and provides an excellent overview of the science and the economics of climate change. It is persuasive in its claim that unless we act to address climate change in a concerted manner now, we may well be gambling with the future of planet earth.

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