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Book Reviews

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The range of books reviewed is wide, covering theory and applications in operations research, statistics, management science, econometrics, mathematics, computers, and information systems (no software is reviewed). In addition, we include books in other fields that emphasize technical applications. Publishers who wish to have their books reviewed should send them to Professor Benjamin Lev. We list the books received; not all books received can be reviewed because space is limited. Those who would like to review books are urged to send me their names, addresses, and specific areas of expertise. We commission all reviews and do not accept unsolicited book reviews. Readers are encouraged to suggest books that might be reviewed or to ask publishers to send me copies of such books.

The authors or editors of the books reviewed in this issue are H. Thomas Bank, Carlos Castillo-Chavez, Wade D. Cook, Joe Zhu, Jaime Gil-Aluja, Abhijit Gosavi, Marc J. Schniederjans, Jamie L. Hamaker, and Ashlyn M. Schniederjans.

BANK, H. THOMAS, CARLOS CASTILLO-CHAVEZ, EDS. 2003. *Bioterrorism: Mathematical Modeling Applications in Homeland Security*. SIAM, Philadelphia, PA. 240 pp. $78.00.

The terrible events of September 11, 2001 have created a new sense of urgency concerning the security of the United States. The threat of bioterrorist acts points to the need for research on ways in which we can anticipate, preclude, and respond to acts of terrorism. In the 10 chapters in this book, the authors describe, for the most part mathematically, ways to address such issues as the control of the rise of fanatical behavior and the spread of influenza in big cities.

A key theme in the book is that discrete mathematics and theoretical computer science have a lot to offer in designing strategies to combat bioterrorism. However, the author of Chapter 1 stresses that before we can benefit from advances in these fields, researchers will need to address two issues. First, although dynamic models have been used in epidemiology for some time, researchers and mathematicians must now "apply today's powerful computational methods to these dynamical systems models . . ." (p. 3). Second, those working in biosurveillance must investigate privacy-preserving computation to enable "parties that have private inputs to compute a joint function of their inputs while ensuring that the computation process itself does not reveal any additional information except for the final output" (p. 9).

Present biochemical sensors typically do not detect small quantities of biological and chemical substances before their dispersion on a large scale. So, how might we improve our understanding of biochemical information? Chapter 3 concerns the working of two sensors, the CFI sensor and the cell-based biosensor. As the authors explain, for dynamic systems, time-series embedding is very useful because this method "allows the construction of a picture of the phase space of the dynamics without writing down the equations of a model" (p. 80). The discussion of mathematical techniques in this chapter is thought provoking. However, as the authors note, the analysis undertaken is problematic because it is not undergirded by a theoretical model of the apposite dimension.

There are various ways of modeling the impact of uncertainty on the behavior of systems, and Chapter 6 concerns two such models: the physiologically based pharmacokinetic (PBPK) model, concerning the effects of drugs, toxins, and viruses on individuals and populations; models based on "remote electromagnetic interrogation pulses" (p. 129) to conduct imaging studies of bulk packages and toxic chemical compounds in tissue. The first kind of model is clearly applicable to bioterrorism. The authors could

have better explained the ways in which the second kind of model is applicable to bioterrorism.

Is it possible to construct and analyze meaningful models of the transmission dynamics of fanatical behavior? Yes, according to the authors of Chapter 7. They discuss a dynamic model in which "the role of recruitment is essential" (p. 156). Their analysis is specialized but very interesting. They show that it is very difficult to completely eliminate a population of fanatics with extreme ideologies because "a small number of individuals in the fanatic class (founder members) may successfully invade the general population" (p. 170). My only complaint with this chapter is the authors' neglect of the pertinent mathematical literature in the social sciences. The authors could have compared their approach and those of Bikhchandani et al. (1992) and Banerjee (1993).

Many chapters in this book contain interesting and thought-provoking discussions of the ways in which rigorous mathematical analysis can increase our understanding of new and not-so-new homeland-security problems. Although in the preface the editors state that mathematical models must be connected to the social, behavioral, and economic sciences, some of the authors apparently think otherwise. Therefore, I cannot unreservedly heap praise on this book, but it will likely interest mathematically-inclined readers who wish to learn how rigorous analysis can help us to develop responses to the problem of bioterrorism.

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Cook, Wade D., Joe Zhu. 2005. *Modeling Performance Measurement: Applications and Implementation Issues in DEA*. Springer, New York. 407 pp. $99.00.

In *Modeling Performance Measurement*, the authors describe their research into data envelopment analysis (DEA) since the mid '90s. They extend the original DEA models to include the use of ordinal data and to facilitate budgeting. The authors strike a balance between extending DEA theory and emphasizing its application to decision making. The book should interest researchers and practitioners.

In each chapter, the authors present a reformulation of the DEA model to suit a particular type of performance-measurement problem. For example, Chapter 4 is on benchmarking. After providing context for benchmarking the authors establish the need for benchmarking, models that can evaluate performance on several measures via one relative efficiency measure and integrated benchmarking. They present two DEA models along with theorems and proofs to establish their correctness and applicability to the problem at hand. They then describe a managerial example to aid practitioners in application. They repeat this pattern in most of the chapters.

Cook and Zhu discuss the difficulties encountered in applying quantitative methods to business problems. In Chapter 5, for example, they write about determining whether a variable is an input or output measure and a two-stage approach that first determines the status of each variable, input or output, and then uses those inputs and outputs in a DEA analysis leading to performance measures for each of the decision-making units (DMUs). In this case, they discuss logistic regression, multiple discriminant analysis, goal programming, and integer goal programming as methods for accomplishing the first stage, while embedding expert knowledge into the model.

In another context, the authors consider the evaluation of capital construction projects, which entails ranking and selecting fundable projects subject to a constrained budget and considering installation cost, operating cost, environmental impact, contribution to capacity, impact on ongoing initiatives, and senior management support. The cost considerations are certainly quantitative, while the others are likely or certainly qualitative. In Chapter 7, the authors describe a method of optimally combining these quantitative and qualitative measures. It may not be reasonable to evaluate some projects, however, on all decision criteria. To solve this problem, the authors developed a model for evaluating an alternative on a proper subset of the full set of criteria using their approach; they examine the performance of an alternative relative to

the ideal performance for that alternative, which they call benevolent evaluation.

Multicriteria decision making is a consistent theme throughout the book, whether in combining multiple measures in benchmarking, evaluating capital construction models, or ranking players in tournaments. In their discussion of the treatment of ordinal criteria and their inclusion in DEA models, the authors present the theory for determining optimal rating scores for decision models that include cardinal and ordinal criteria and the results.

They consider resource allocation in a DEA context using qualitative criteria and also allowing for partial funding of alternatives. Especially interesting is the method of determining a set of multipliers to aggregate several managers' opinions of the impact of increasing or decreasing the budgets for all projects using a preemptive linear-programming model. This approach allows aggregation of managers' opinions into an overall consensus set of ratings, which are then used as inputs for the resource (re)allocation integer programs. Cook and Zhu present a numerical example.

Another form of performance-measurement modeling is project prioritization with resource constraints. Individual projects make contributions in several areas, such as capacity, profit, and new capabilities. They also require resources from several areas, such as budget and available labor. One could use a binary knapsack representation to solve this type of problem, which would require some objective evaluation multiplier for each project. The difficulty with these problems is that such an objective multiplier may not exist or may be subject to dispute among the interested parties. Cook and Zhu propose to solve this difficulty by allowing those proposing each project to evaluate it using a binary choice, DEA-based approach. They describe two examples of this extension to DEA; a research-and-development project prioritization and a site-selection problem for a chain of retail stores.

Aggregating preference ranking has been a problem of interest for over 200 years (Borda 1781). The existing preference-aggregation models can be considered deficient because they don't provide a fair composite evaluation of the first-place, second-place, third-place standings, and so on. Cook and Zhu present a model that derives a set of fair multipliers. Part of their definition of fair is that the set of multipliers for each candidate may differ from those for any other candidate. Using this definition, they can calculate the most favorable standing for each candidate.

In the last chapter, the authors discuss hierarchies of decision-making units. The authors describe a model for determining the efficiency of group decision-making units and individual decision-making units along with numerical results from a study of power plants in Canada. They point out the need for further research in this area.

The software included with the book, *DEAFrontier* (www.deafrontier.com), is a Microsoft Excel add-in that uses the built-in solver. It includes the models discussed in the book.

I recommend *Modeling Performance Measurement* to researchers and practitioners.

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GIL-ALUJA, JAIME. 2004. *Fuzzy Sets in the Management of Uncertainty*. Springer-Verlag, New York. 420 pp. $169.00.

Gil-Aluja guides us on a stimulating journey from Aristotle (384–322 B.C., "...with regards to things present and past, propositions, whether positive or negative, are by necessity true or false") to Zadeh (1965) with his fuzzy sets that created alternative research road maps within scientific fields. In this mathematical and philosophical trip, many scientists have been the driving forces, among them the author. Gil-Aluja, born in 1936 in Tarragona, has written over 15 books, most in collaboration with his close friend, a French mathematician, the late Arnold Kaufmann. In this monograph, Gil-Aluja covers theoretical and technical elements of fuzzy sets that will help us to face the uncertainties of the future. He gives a sequence of examples and stories to make his presentation of advanced formulations as friendly as possible.

He begins the book with an excellent chapter titled "Uncertainty in business management." He ends his summary of current problems in business management with the confession that,

> The time is not too far away when it was possible to make estimates on future values taking as reference data from the past, because it could be stated that the outcome of the events would be a prolongation of those that had already occurred. To believe that this continues to be so today is, in many cases, to deceive ourselves (p. 14).

In light of this statement, the rationale for using fuzzy sets in managing uncertainty becomes clear. The author goes on to discuss ways of measuring and evaluating business phenomena. Inevitably he discusses various authors' views on probability and uncertainty; those of Pascal, Laplace, Borel, and Kolmogorov, for example. Starting from Aristotelian logic, Gil-Aluja leads us to the foundation of his logic, the principle of gradual simultaneity: "A proposition can be at one and the same time true and false, on the condition of assigning a degree to its truth and a degree to its falseness" (p. 33). In the last paragraph of this chapter, he discusses the idea of the fuzzy subset and an example of the threshold in forming a family.

In Chapter 2, "The setting up a business," the author starts with determining the viability of a business and the minimum level of activity. He then covers forecasting future events by the Delphi method. The Delphi method is appropriate for surveys, which use anonymity, controlled retroaction, and the statistical response of the group. The author provides a thorough description of the fuzzy Delphi method and closes the chapter by describing the "counter expertise" type of analysis.

"The investment process" is the title of Chapter 3. Investment processes include setting up a business, expanding it, renewing facilities, and changing activities. The author discusses in detail the levels of presumption and the use of the hendecagonal semantic scale and concludes with an advanced section on updating rates from fuzzy triangular numbers.

In Chapter 4, Gil-Aluja discusses how to draw up a budget, considering the ideal budget and the so-called flexible budget. He discusses zero-base budgeting and extends it to fuzzy-zero-base budgeting by using triangular fuzzy numbers. In trying to overcome the difficulty of assigning only a single value to the maximum presumption, that is, the amount of money assumed to be the most one could spend at the corresponding budget level (the central number of the fuzzy triangular number), he uses "fuzzy trapezoidal numbers." This gives businessmen the option of expressing their opinions in terms of a value below which the business would not incur the expense (lower extreme), a value above which it would not incur the expense (upper extreme), and two limits between those, which they feel represent the range in which the business would incur the expense (maximum presumption, p. 165), meaning that the presumption is defined as a confidence interval.

Chapter 5, "Economic treatment of fixed assets" concerns the adverse minimum and the fuzzy-average-adversity method.

In Chapter 6, on managing human resources, the author begins with personnel selection. He proposes a decomposition approach to this task and the use of semantic scales in each phase and test. One can evaluate candidates and reach a verdict using somewhat advanced formulas. Gil-Aluja raises the problem of assigning employees and describes an algorithm that provides good answers to the problem, not optimum. To find out whether a better solution exists, he uses the Hungarian algorithm (König 1916, Kuhn 1955). The author concludes the chapter with the idea of making employees interchangeable by training homogeneous groups.

In Chapter 7, the author discusses accounting as a support to financial analysis, provisional financial statements and uncertainty, profitability, and solvency. He describes the use of fuzzy ratios in detail. In Chapter 8, "Distribution in commercial activity," the topics include the search for distribution channels, preferences among points of sale, the use of various channels, and distribution through homogeneous groups. In the final chapter, "The image of a business," the author covers instruments for transmitting a business's image to the different levels of the society.

In the epilogue, Gil-Aluja says, "We have been guided by the hope to contribute a very small grain of sand to the marvellous beach of Knowledge," making crystal clear his modesty throughout his academic life.

Gil-Aluja's book is unusual in its focus on business management from a fuzzy-theory perspective. Other fuzzy-oriented books, for example, Klir and Folger's (1988), do not have that focus, and other monographs from Springer's series *Studies in Fuzziness and Soft*

Computing cover other aspects of fuzzy theory and are extremely technical.

Springer-Verlag's publications are usually mathematically rigorous, but advanced mathematics are absent from this book. Gil-Aluja's book is clearly written and does not include too much math; however, it cannot be used as a textbook because it contains no exercises, Web references, or supporting Web portal. It would be an excellent reference in courses on fuzziness, uncertainty management, business theory, and decision making.

Negative factors are the many references in Spanish and the book's price.

In conclusion, Gil-Aluja's book should interest anyone applying fuzzy logic to management. He focuses on problems of planning, programming, and control and elucidates the entire financial network. The level of mathematics escalates gradually, making the book attractive to both researchers and practitioners. It definitely deserves a place on your bookshelf.

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GOSAVI, ABHIJIT. 2003. *Simulation-Based Optimization: Parametric Optimization Techniques and Reinforcement Learning*. Kluwer Academic Publishers, Dordrecht, The Netherlands. 554 pp. $160.00.

Optimization and simulation are two very important techniques of operations research. A book integrating them has a good chance of attracting the attention of operations researchers. In the preface (p. xxv), to *Simulation-Based Optimization*, Gosavi writes, "If you are working on a problem that involves a stochastic system, and if the problem is one of optimization, you are likely to find a useful material here." The subject of the book is optimization of stochastic objective functions. In practical applications, one normally obtains the values of such functions with Monte-Carlo simulation. Gosavi calls this topic simulation-based optimization. He promises: "...to introduce the reader to the newly emerging and exiting topic of simulation-based optimization" (preface, p. xxv). Indeed, it is an exiting topic, but is it newly emerging? The classical paper on this topic, by Kiefer and Wolfowitz, is dated 1952. Methods of optimization of noisy functions have been intensively investigated for 50 years and have been covered in many publications (Chen 2002). A rich literature exists on this topic in Russian (Ermoljev 1976, Rastrigin 1968). Possibly, by "newly emerging," the author is simply emphasizing new practical applications. But they are not a breakthrough since stochastic optimization typifies the synergy between mathematical theory and applications, for example, in signal processing and design of adaptive control systems (Chen 2002, Tsypkin 1971).

Gosavi begins with some definitions and elementary probability theory. He introduces the basic concepts of simulation, response surfaces, and artificial neural networks. He devotes a chapter (about 40 pages) to parametric optimization, with continuous optimization represented by the gradient-descent method and the Nelder-Mead method. Although the book is oriented toward stochastic optimization, the simultaneous perturbation method is the only method suitable for stochastic optimization covered in this chapter. For simulation-based optimization problems, one can seldom prove the unimodality of an objective function. Therefore, global minimization of noisy functions is important in various applications (Torn and Zilinskas 1989), but Gosavi does not discuss this problem. His presentation of discrete optimization methods is more complete. He describes two selection methods, Rinott and Kim-Nelson, and several metaheuristic search methods (simulated annealing, genetic algorithms, tabu search, and learning automata search). Chapter 11 (about 30 pages) is "Convergence: Background material." Gosavi introduces elementary definitions and concepts, for example, he defines a vector space and convergence conditions for sequences. In the first half of Chapter 12, "Convergence analysis of parametric optimization methods," he defines continuous functions, Taylor's theorem, the necessary conditions

of unconstrained minimum. In the second half, he proves the convergence of the gradient descent method and the convergence of the simultaneous perturbation method and discusses simulated annealing.

Gosavi devotes most of the book to special problems of optimal stochastic control. He introduces the concept of a Markov chain and considers an optimal deterministic stationary decision related to the Markov chain. The optimal decision consists of actions at each state of the chain that maximize average or discounted reward. Gosavi uses dynamic programming to find the optimal decision. However, applying dynamic programming directly is difficult because of the well-known curse of dimensionality. To cope with this difficulty, one can combine approximation and estimation methods with the dynamic-programming method. Different authors call such modified dynamic-programming methods by different names, for example, neuro-dynamic programming or reinforcement learning. Gosavi describes his extension of dynamic programming in a chapter titled "Reinforcement learning." In the following chapter, the author considers the convergence of standard dynamic programming and reinforcement-learning algorithms. He finishes presenting the algorithms in a chapter on case studies, discussing the classical inventory problem, airline yield management, preventive maintenance, and several other topics.

The last chapter of the book (about 100 pages) contains the code for the various algorithms considered, which could have been made available on a CD or via the Internet: random-number generation, dynamic programming, artificial neural networks, and reinforcement learning.

The book's 15 chapters include long chapters on "Dynamic programming," "Reinforcement learning," "Convergence: Control optimization," and "Codes." The book favors optimal stochastic control and slights parametric optimization.

Students and researchers in industrial engineering, computer science, operations research, and applied mathematics are listed on the back cover of the book as a targeted audience. However, for this audience, the book has some disadvantages. Much of it consists of elementary material typically covered in undergraduate courses in statistics and calculus and of elementary material on parametric optimization. Researchers might prefer a book that focused on new applications of stochastic dynamic programming. For use as an undergraduate textbook, the book seems poorly balanced. For a course on simulation-based optimization, the author pays too little attention to simulation concepts and parametric optimization and too much to stochastic dynamic programming. As a textbook for an advanced course on applications of stochastic dynamic programming, the book contains too much redundant elementary material. People working in industry, however, have often forgotten mathematics but need to apply advanced methods. They seek a refresher on mathematics and a description of advanced methods in one book. Gosavi's book seems most suitable for independent study and as a textbook for courses oriented to practicing engineers interested in optimizing real-world stochastic systems.

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Schniederjans, Marc J., Jamie L. Hamaker, Ashlyn M. Schniederjans. 2004. *Information Technology Investment Decision Making Methodology.* World Scientific Publishing Co., River Edge, NJ. 389 pp. $78.00.

Schniederjans, Hamaker, and Schniederjans intended *Information Technology Investment Decision Making Methodology* to be a textbook for an upper-level undergraduate course or a graduate-level course for business management students, as well as a guide for managers at various levels in industry who have to handle information technology (IT) investment deci-

sions. They aim to provide an in-depth treatment of a wide variety of decision-making methods relevant to investments in IT.

The book is organized into four major parts. Part 1 is introductory, containing chapters on various types of IT-investment decision problems, IT needs analysis, IT-investment strategies, and IT-investment performance measures. Part 2 concerns financial methods; Part 3 multicriteria methods; and Part 4 benchmarking, investment-portfolio methods, and value analysis. The 12 chapters are each well packed with illustrative examples, tables, and graphics that should succeed in meeting the learning objectives, listed at the start of each chapter. Discussion questions, concept questions, and references at the end of each chapter add to the book's tutorial value.

One of the interesting features of the book is a set of tables listing a variety of techniques for IT-investment decision making. About 10 "financial techniques," about seven "OR/MS techniques," and 20-odd "techniques specifically designed for IT investment decision making." Included in the latter category are such techniques as Bedell's method, Buss's method, an information-economics method first proposed by Parker, Benson, and Trainor (1989) in *Information Strategy and Economics*, the balanced scorecard method first introduced by Kaplan and Norton (1992) for evaluating organizational performance but since adapted by Douglas and Walsh (1992) for IT decision making. The authors do not describe all these techniques in detail, they say enough to provide an overall idea of the techniques, and they list references to the original, detailed expositions. Schniederjans et al. have done a commendable job in bringing together a fairly large and diverse set of techniques scattered over a number of books and journals.

Also noteworthy are the inclusion of multifactor scoring methods (MFSM) and the discussion of the analytical hierarchy process (AHP) pioneered by Thomas Saaty (1980). The authors discuss weighted and unweighted MFSMs and illustrate them with numerical examples. The authors rightly describe the AHP as "…a complete decision making process that permits a more complete consideration of multifactors or multi-criteria than the MFSMs, and as such is ideal for aiding in the multi-factor environment of IT investment decision making." In fact, the principal author of this book was one of the pioneers in applying the AHP to IT-investment decision making, and the discussion of the AHP technique in the book is quite extensive and lucid. The numerical example worked out in detail should give any reader a good grasp of this technique as applied to IT-investment decision making.

The book concludes with an interesting epilogue on the costs of not making the right IT decisions. It is a sort of philosophic piece, enlivened by quotes from a number of prominent personalities, past and present, such as Isaac Asimov, Theodore Roosevelt, Donald Rumsfeld, and Mark Twain. The authors discuss the larger issues in IT-investment decision making and the caveats to keep in mind when using any of the techniques they discuss. They distill the wisdom and experience of a number of scholars and researchers, besides themselves, in the complex art and science of IT-investment decision making. They present this wisdom and experience in the form of seven "strategies" which, they claim, have proven themselves in IT-investment decision making.

Instead of *strategies*, a more appropriate word would be *principles*, and I see two of their principles as very important: First, "Executive managers, not IT managers, should determine strategic allocation decisions" (p. 374). This principle seems valid in all walks of modern life, namely, that strategic decisions regarding any major technology are too important to be left to the professionals in that technology; they must be made by the person or persons who have a larger social responsibility. For example, strategic decisions on nuclear technology are too important to be left to nuclear scientists; strategic decisions in genetic engineering are too important to be left to geneticists; and so on.

The second principle is, "Recognize in all the selection processes mentioned above that the IT manager has potential biases that can preclude the right IT decision choice from the analysis" (p. 376). Anyone who has been involved in IT-investment decision making will endorse the truth in this principle. The operative word here is *preclude*; the authors are saying that some choices will not even be considered in the analysis. The two principles go hand in hand, and it behooves the executive manager responsible for the final decision to be well enough informed to see that all choices are considered.

Robert Browning, the celebrated English poet, writes in "Rabi Ben Ezra" that "Our joys are sometimes three parts pain. . . ." He does not specify three parts out of how many, but I want to end by remarking that my joys in reviewing the book were also three parts pain, and that is three parts in a hundred. The pain was occasioned by several instances of sloppy editing or proofreading, for example, "This is way [sic] we call right-hand side b values 'targets' or 'goals' in a GP model" (p. 256) and ". . . double check our final decisions to see if we have in fact been bias [sic] in some way" (p. 377). Nevertheless, the book is a fine piece of work, and it should prove useful to students and practitioners alike.

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