633 LECTURE NOTES IN ECONOMICS AND MATHEMATICAL SYSTEMS

Kurt Marti
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(Editors)

Coping with Uncertainty

Robust Solutions

Springer

Lecture Notes in Economics and Mathematical Systems 633

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ISSN 0075-8442
ISBN 978-3-642-03734-4 e-ISBN 978-3-642-03735-1
DOI 10.1007/978-3-642-03735-1
Springer Heidelberg Dordrecht London New York

Library of Congress Control Number: 2009934495

Cover design: SPi Publisher Services

Printed on acid-free paper

Springer is part of Springer Science+Business Media (www.springer.com)

Preface

The aim of the series of workshops on "Coping with Uncertainty" (*CwU*) organized at IIASA, Laxenburg, Austria, has been to provide researchers and practitioners from different areas with an interdisciplinary forum for discussing various ways of dealing with uncertainties in diverse areas, including environmental and social sciences, economics, policy-making, management, and engineering. The workshops proved to be successful, especially in cross-disciplinary sharing methods, ideas, and open problems.

Science-based support for addressing the on-going global changes needs solutions for fundamentally new scientific problems, which in turn require new concepts and tools. A key issue concerns a vast variety of practically irreducible uncertainties, including potential extreme events of high multidimensional consequences, which challenge traditional models, and thus require new concepts and analytical tools. This type of uncertainty critically dominates, e.g., the climate change debates. In short, the dilemma is concerned with enormous costs versus massive uncertainties of potentially extreme impacts. Traditional scientific approaches usually rely on real observations and experiments. Yet no sufficient observations exist for new problems, and "pure" experiments, and learning by doing may be very expensive, dangerous, or simply impossible. In addition, the available historical observations are often contaminated by "experimentator", i.e., past actions, and policies. The complexity of new problems does not allow us to achieve enough certainty just by increasing the resolution of models or by bringing in more links. They require explicit treatment of uncertainties using "synthetic" information composed of available "hard" data from historical observations, the results of possible experiments, and scientific facts as well as "soft" data from experts' opinions, scenarios, stakeholders, and public opinion. As a result of all these factors, our assessment will always have poor estimates. Therefore, the role of science-based support for addressing the new problems increasingly changes from the traditional "deterministic predictions" analysis to the design of strategies that are robust against the involved uncertainties and risks.

This volume contains contributions based on selected presentation at the *CwU* 2007 workshop. The workshop aimed at contributing to a better understanding between practitioners dealing with the safety of complex systems under uncertainty, and scientists working on either corresponding modeling approaches, or on methods that can be adapted for improving the understanding and management of

uncertainty. The focus of the *CwU* 2007 was on novel approaches to supporting robust decision-making and design, especially when uncertainty is irreducible, consequences might be enormous, and the decision process involves stakeholders with diverse interests. Presentations dealt with open problems in this field, limitations of known approaches, novel methods and techniques, or lessons from applications of various approaches. In particular, contributions on the following issues were presented:

- Modeling different types of uncertainty (probabilistic and non-probabilistic)
- The formulation of appropriate deterministic substitute problems for different types of uncertainty
- Robustness of efficient solutions with respect to inherent uncertainties
- Simulation tools (for optimal decision/design under uncertainty)
- Safety and security of humans, environment, and vital infrastructure facing catastrophe risks
- Lessons that can be learned from designing and operating highly reliable systems
- Downscaling and discounting methods for handling spatial and temporal scales
- Benefits and costs of (partial) postponing decisions (aimed at reducing uncertainties)
- Open problems in the adequate treatment of uncertainties
- Concrete applications in economics, finance, engineering, energy, population, air quality, climate change, ecology, forestry, and other environmental problems

The workshop was organized at IIASA in December 2007, jointly by:

* IIASA – International Institute for Applied Systems Analysis, Laxenburg, Austria
* Federal Armed Forces University Munich, Germany

The scientific Program Committee included: Yuri Ermoliev, IIASA, Laxenburg (A); Leen Hordijk, IIASA, Laxenburg (A); Marek Makowski, IIASA, Laxenburg (A); Kurt Marti, Federal Armed Forces University Munich (D); Gerhard I. Schuëller, University of Innsbruck (A).

The organizers gratefully acknowledge the support of:

– GAMM – International Association of Applied Mathematics and Mechanics, and
– IIASA – International Institute for Applied Systems Analysis

Their generous support enabled the participation of many researchers who otherwise could not have attended the Workshop.

This volume contains chapters based on selected presentations at the *CwU* 2009 and an introductory short summary of the key issues related to the robust solutions. The chapters are organized into the following four parts:

1. *Modeling of uncertainty* discusses descriptions of uncertainties of different types (probabilities, theory of evidence and possibility, imprecise probabilities, fuzzy sets and variables).

2. *Robust solutions under uncertainty* presents new approaches to discounting applied to evaluation of investments for catastrophic risk management, and to cost-effective and environmentally-safe emission trading under uncertainties, as well as modern quantitative modeling methodologies for analysis of network risks and design of robust networks under uncertainty.
3. *Analysis and optimization of technical systems and structures under uncertainty* deals with state estimation of dynamical systems in case of uncertainties of initial conditions and dynamic parameters described by means of certain ellipsoids, and with the derivation of stochastic linear programs for the reliability-based optimization of plane frames under stochastic uncertainty with respect to external loadings and material parameters.
4. *Analysis and optimization of economic and engineering systems under uncertainty* discusses the variability of the atmospheric deposition of nitrogen in the sea, the treatment of risks and uncertainties in planning agricultural production allocation and expansion, the uncertainty in greenhouse gas emission estimates, consequences of the weather forecasts for the optimal control of agricultural production, and the estimation error in retrieving carbon dioxide column abundances obtained from the GOSAT satellite.

We express our gratitude to all referees, and we thank all authors for the timely delivery of the final version of their contributions to this volume. Furthermore, we thank Ms Elisabeth Lößl of the Federal Armed Forces University Munich for her support in the preparation of this volume. Finally, we thank Springer-Verlag for including the Proceedings in the Springer Lecture Notes Series "LNEMS".

Munich, Laxenburg
June 2009

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