

Preface

The topic of this book is multistage stochastic optimization. *Multistage* reflects the fact that an optimal decision is an entire strategy or policy, which is executed during subsequent instants of time, or in successive stages. The term *stochastic* emphasizes the fact that unforeseen events may happen during this process. This can be in favor of the initial goal or even jeopardizing the success of the entire task. The decision maker then will react to this new situation and take respective measures to ensure the initial goal.

These types of optimization problems are natural and common in managing and planning processes. Especially in an economic environment it is an everyday situation that incidents occur or new information is revealed, which influence the original goal. Those events require a respective response action by the decision maker: in logistics and production, incidents like machine or transport systems breakdowns, as well as new information about demands will require adaptive decisions. Fund managers will adjust the strategy on a regular (say weekly) basis in order to achieve the long-term investment goal. More generally, many managerial or planning supervisions are designed to keep track and to meet a predefined goal. Meetings on a regular basis are typically held to evaluate the current situation and to resolve actions or reactions.

The stochastic character of the problem might imply that there is some risk that the initial goal is not met. This respective risk is addressed as well and strategies to comply with this intrinsic risk are part of the optimization problem.

The present book is organized as follows. Chapter 1 of this book (Introduction) addresses typical situations, which give evidence that multistage decision making is superior to myopic single-stage decisions. It also sets the mathematical outline and addresses important principles and problem solution techniques.

Uncertainty in decision relevant data is expressed in terms of discrete stochastic processes, which can be represented as scenario trees. As trees are the basic data structures, concepts of distances are introduced and studied in detail in Chap. 2.

These distances allow measuring the deviation of the simplified decision model from the underlying, more complex model, and they allow comparing two decision models. Measuring this deviation gives a kind of quality control.

Risk and utility functionals are introduced in Chap. 3. It is their role to quantify the risk, which is associated with the current problem; they provide either goals (minimize risk) or constraints (risk should not exceed a given risk limit) for the decision situation at hand.

Chapter 4 demonstrates how the process should be organized which leads from observed data to viable optimization models, which are mostly just approximations of the reality. The quality of approximations is crucial for the quality of the decisions.

An important aspect in multistage optimization is time consistency. That is, for short, that optimal strategies, found at the beginning of the process, remain optimal in later stages and no change of strategies is necessary. Chapter 5 addresses time consistent decisions as well as some situations of time inconsistency.

A basic assumption in stochastic optimization is that the random outcomes of the scenario process are not known at the time of decision making, but the model for the random distributions is known. This assumption is relaxed in Chap. 7. Inexact knowledge of the probability model is called model ambiguity. In ambiguous situations the decisions are not only subject to outcome risk (aleatoric risk) but also to modeling errors (epistemic risk, i.e., the risk of having chosen the wrong distribution model). The decision maker is confronted not only with the random errors (aleatoric errors) but also with the fact that observations are obtained empirically and thus do not reflect the real world situation. The final chapter (Chap. 8) contains some examples of larger multistage optimization problems.

It is the intention of the book to summarize modern modeling aspects, provide theoretic foundations as well as some solution techniques. The book moreover summarizes the current status of research in multistage stochastic optimization. For this reason and in order to provide a comprehensive and complete presentation this book adapts content and results from previous publications and from currently unpublished manuscripts. This is made evident by proper citations wherever possible.

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A list of typos and errata will be maintained at Georg Pflug's homepage
<http://homepage.univie.ac.at/georg.pflug>.

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