Preface

There are four main reasons why I wrote this book. First, six sigma consultants have taught us that people do not need to be statistical experts to gain benefits from applying methods under such headings as "statistical quality control" (SQC) and "design of experiments" (DOE). Some college-level books intertwine the methods and the theory, potentially giving the mistaken impression that all the theory has to be understood to use the methods. As far as possible, I have attempted to separate the information necessary for competent application from the theory needed to understand and evaluate the methods.

Second, many books teach methods without sufficiently clarifying the context in which the method could help to solve a real-world problem. Six sigma, statistics and operations-research experts have little trouble making the connections with practice. However, many other people do have this difficulty. Therefore, I wanted to clarify better the roles of the methods in solving problems. To this end, I have re-organized the presentation of the techniques and included several complete case studies conducted by myself and former students.

Third, I feel that much of the "theory" in standard textbooks is rarely presented in a manner to answer directly the most pertinent questions, such as:

Should I use this specific method or an alternative method?

How do I use the results when making a decision?

How much can I trust the results?

Admittedly, standard theory (e.g., analysis of variance decomposition, confidence intervals, and defining relations) does have a bearing on these questions. Yet the widely accepted view that the choice to apply a method is equivalent to purchasing a risky stock investment has not been sufficiently clarified. The theory in this book is mainly used to evaluate in advance the risks associated with specific methods and to address these three questions.

Fourth, there is an increasing emphasis on service sector and bioengineering applications of quality technology, which is not fully reflected in some of the alternative books. Therefore, this book constitutes an attempt to include more examples pertinent to service-sector jobs in accounting, education, call centers, health care, and software companies.

In addition, this book can be viewed as attempt to build on and refocus material in other books and research articles, including: Harry and Schroeder (1999) and Pande *et al*. (2000) which comprehensively cover six sigma; Montgomery (2008) and Besterfield (2001), which focus on statistical quality control; Box and Draper

(1987), Dean and Voss (1999), Fedorov and Hackl (1997), Montgomery (2000), Myers and Montgomery (2001), Taguchi (1993), and Wu and Hamada (2000), which focus on design of experiments.

At least 50 books per year are written related to the "six sigma movement" which (among other things) encourage people to use SQC and DOE techniques. Most of these books are intended for a general business audience; few provide advanced readers the tools to understand modern statistical method development. Equally rare are precise descriptions of the many methods related to six sigma as well as detailed examples of applications that yielded large-scale returns to the businesses that employed them.

Unlike many popular books on "six sigma methods," this material is aimed at the college- or graduate-level student rather than at the casual reader, and includes more derivations and analysis of the related methods. As such, an important motivation of this text is to fill a need for an integrated, principled, technical description of six sigma techniques and concepts that can provide a practical guide both in making choices among available methods and applying them to real-world problems. Professionals who have earned "black belt" and "master black belt" titles may find material more complete and intensive here than in other sources.

Rather than teaching methods as "correct" and fixed, later chapters build the optimization and simulation skills needed for the advanced reader to develop new methods with sophistication, drawing on modern computing power. Design of experiments (DOE) methods provide a particularly useful area for the development of new methods. DOE is sometimes called the most powerful six sigma tool. However, the relationship between the mathematical properties of the associated matrices and bottom-line profits has been only partially explored. As a result, users of these methods too often must base their decisions and associated investments on faith. An intended unique contribution of this book is to teach DOE in a new way, as a set of fallible methods with understandable properties that can be improved, while providing new information to support decisions about using these methods.

Two recent trends assist in the development of statistical methods. First, dramatic improvements have occurred in the ability to solve hard simulation and optimization problems, largely because of advances in computing speeds. It is now far easier to "simulate" the application of a chosen method to test likely outcomes of its application to a particular problem. Second, an increased interest in six sigma methods and other formal approaches to making businesses more competitive has increased the time and resources invested in developing and applying new statistical methods.

This latter development can be credited to consultants such as Harry and Schroeder (1999), Pande *et al*. (2000), and Taguchi (1993), visionary business leaders such as General Electric's Jack Welch, as well as to statistical software that permits non-experts to make use of the related technologies. In addition, there is a push towards closer integration of optimization, marketing, and statistical methods into "improvement systems" that structure product-design projects from beginning to end.

Statistical methods are relevant to virtually everyone. Calculus and linear algebra are helpful, but not necessary, for their use. The approach taken here is to minimize explanations requiring knowledge of these subjects, as far as possible.

This book is organized into three parts. For a single introductory course, the first few chapters in Parts I and II could be used. More advanced courses could be built upon the remaining chapters. At The Ohio State University, I use each part for a different 11 week course.

The second edition features a greatly expanded treatment of lean manufacturing and design for six sigma (DFSS). Specifically, many lean methods have been added to Chapter 5, and Chapter 21 is entirely new. Also, there is additional design of experiments (DOE) related introductory material in Chapter 10. The new material includes coverage of full factorials, paired t-testing, and additional coverage of analysis of variance (ANOVA). Finally, several corrections have been made particularly relating to design of experiments theory and advanced methods.

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