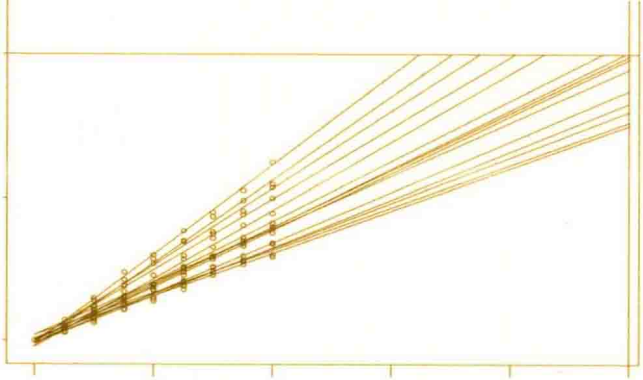
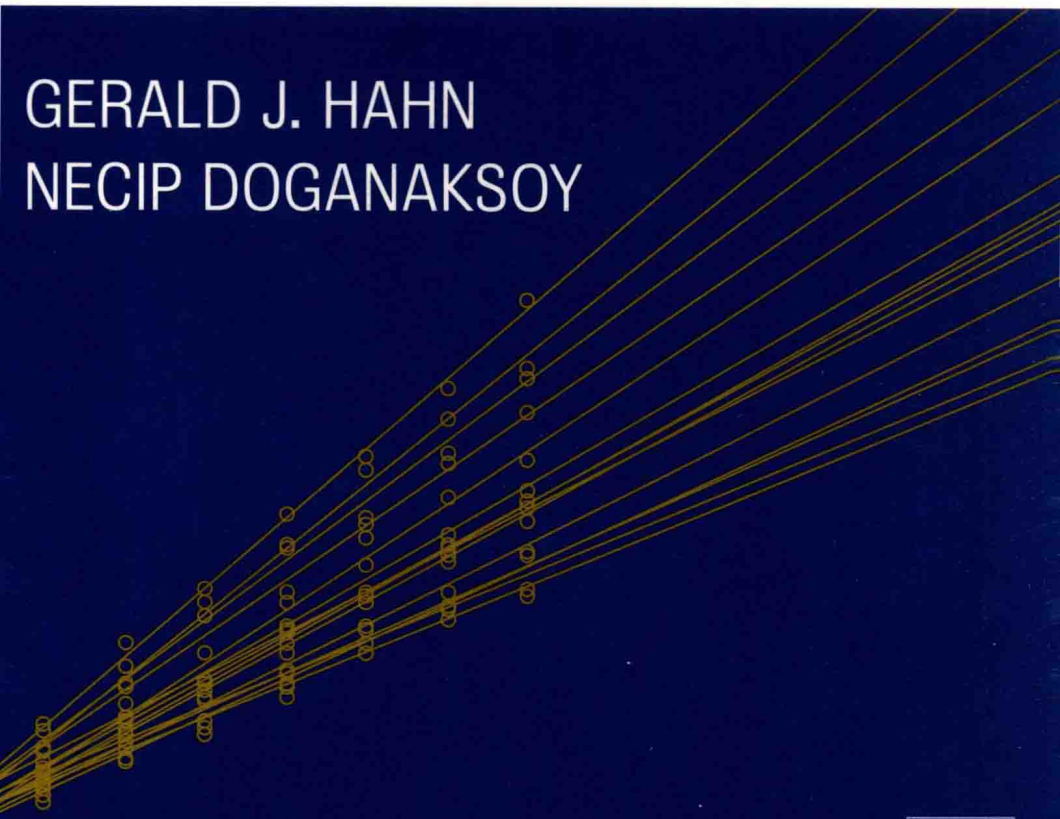


THE ROLE OF STATISTICS IN BUSINESS AND INDUSTRY

GERALD J. HAHN
NECIP DOGANAKSOY



WILEY

ftp://
SITE AVAILABLE

THE ROLE OF STATISTICS IN BUSINESS AND INDUSTRY

GERALD J. HAHN
Retiree, GE Company
Schenectady, New York

NECIP DOGANAKSOY
GE Company
Schenectady, New York

With the assistance of William P. Alexander, Tim K. Keyes, William Q. Meeker, and Robert R. Starbuck

WILEY
A JOHN WILEY & SONS, INC., PUBLICATION

Published by John Wiley & Sons, Inc., Hoboken, New Jersey.
Published simultaneously in Canada.

Library of Congress Cataloging-in-Publication Data:
Hahn, Gerald J.
The role of statistics in business and industry / Gerald J. Hahn, Necip Doganaksoy.
p. cm.
Includes bibliographical references and index.
ISBN 978-0-471-21874-6 (pbk.)
1. Mathematical statistics. 2. Commercial statistics. I. Doganaksoy, Necip, 1960– II. Title.
QA276.H2195 2008
519.5–dc22

2008007357

Printed in the United States of America.

10 9 8 7 6 5 4 3 2 1

To Bea and Reyhan for their love and patience and to our children and grandchildren (current and future).

MAJOR APPLICATIONS

PREFACE

OUR GOAL

We asked a recent Ph.D. in statistics what was the biggest surprise in her first year working as an applied statistician in business and industry. "I was amazed at how little I really knew, even about subjects about which I felt I knew a lot" she answered unhesitatingly. Her response motivated us to write this book.

Most texts on statistics describe the major technical tools (from summary statistics and statistical inference to analysis of variance and multiple regression) upon which the subject is based and then try to show how these are employed. We do the reverse. We describe key problems in business and industry from product design to field support and then show how statistics is used to address them. In doing so, we leverage the insights gained from our combined 70 years in the trenches as applied statisticians. Our major aim is to help readers worldwide become valuable contributors on the job by providing them with insights into the types of problems they are likely to encounter and how statistics is used to address them.

This book should be especially useful to:

- Students in statistics and related areas who want to learn how statistics is used in business and industry.
- Practicing statisticians who wish to increase their effectiveness.
- Those in fields other than statistics, who are, or wish to be, local statistical experts; for example, technically oriented Six Sigma black belts and master black belts.
- MBAs and other specialists who wish to use data for better business decision making.

In addition, this book should be of interest to:

- Students who have been intrigued by an introductory college, or possibly high school, statistics course and are trying to decide whether to go for a career in applied statistics.
- Academicians who want to add more practical applications to courses they teach in statistics.
- Managers who would like to get a better understanding of how their operations can benefit from statistics.
- Teachers of high school Advanced Placement courses in statistics in the U.S. who want to make their courses more meaningful and better guide students.

We address readers with a wide range of backgrounds – only a one-semester introductory course in statistics is assumed. Some technical concepts that we regard as important, but are not typically taught in an introductory course are reviewed, e.g., product life distributions (as an Appendix to Chapter 5) and the design of experiments and simulation (in Chapter 3).

The book can serve as a supplemental text and instructor's guide for introductory courses on applied statistics and statistical consulting. It is also well suited as the prime text for a second course in applied statistics and for self-study by early-career statisticians and practitioners.

TOPICS AND EMPHASIS

This book has three parts:

- Setting the stage: Overview of the role of statistics in general, and in business and industry, in particular.
- Manufactured product applications. Chapters on the role of statistics in product design (concepts and example), reliability assurance, manufacturing quality improvement (concepts and example), further manufacturing applications and product field support.
- Other applications: Chapters on the role of statistics for pharmaceutical products, financial services, business processes and further applications (including the food, beverage and related industries, semiconductor products, telecommunications and statistical imaging).

We place heavy emphasis on getting the right data – a fundamental subject that is often brushed aside in favor of discussions of statistical methods. Also we urge that those applying statistics play a proactive role in projects as team members. This calls, for example, for early involvement during the design of a product and continued participation throughout the product's life cycle.

SCOPE

Our comments reflect our many years as company-wide statistical resources for a global conglomerate (GE). This has involved us in a rich diversity of problems dealing with the design and manufacture of a wide variety of products (e.g., household appliances, locomotives, plastics, turbines, semiconductors). In addition, we have been engaged in service applications both with businesses whose major function is to provide a service (e.g., commercial and consumer finance, television networks) and with service or business applications (e.g., scheduling, marketing, field servicing) for operations that manufacture products.

To broaden the scope further, we have invited four contributing authors to prepare two chapters and critically review the others. They are:

- Robert R. Starbuck (Assistant Vice President, Special Projects, Wyeth Research) who wrote the chapter on pharmaceutical products.

- William P. Alexander (Director of Quantitative Research, Wachovia Securities) and Tim K. Keyes (Manager, Strategic Portfolio Decisioning, Corporate Financial Services, GE) who wrote the chapter on financial services applications.
- Professor William Q. Meeker (Professor of Statistics and Distinguished Professor of Liberal Arts and Sciences at Iowa State University) who added further perspective based on his academic and broad consulting experience.

Also, Colin McCulloch (Statistician, GE Global Research Center) wrote the section on statistical image analysis in the chapter on Further Applications.

Our original intent was to include in this volume a detailed discussion about the environment in which statisticians work today and some of the nontechnical challenges they face, and to provide some added important technical pointers. We have, in fact, drafted much of this material. Due to our (and our editors') desire to keep this book reasonably short, we have decided to leave these topics for future books.

STATISTICIANS AND PRACTITIONERS

In addition to discussing the role of statistics, we talk about what statisticians do. Our concept of a statistician, however, is not limited to those with formal degrees in the subject. It also encompasses those with significant statistical knowledge and understanding, often acquired by a combination of experience and self-study. Such statistically oriented individuals might not regard themselves as statisticians, but are still often considered to be local "statistical experts" by their peers.

We employ the term "practitioners" to refer to those who use statistics, but whose knowledge and interest in the subject is more limited, such as engineers who use point-and-click statistical software to analyze data. The number of such practitioners is increasing rapidly with the improved accessibility to databases and the availability of easy-to-use statistical software.

OTHER FEATURES

We rely heavily on specific examples and use these to illustrate key points. Some of these examples are presented in great detail and, on occasion, precede the discussion of the principles that they illustrate and run throughout an entire chapter. Most are adapted from actual problems that we, or the contributing authors, have encountered.

We conclude most chapters with a summary of "major takeaways" and two types of discussion questions. General questions are directed at readers with limited statistical training. Technical questions are meant for those who have knowledge of statistics beyond the introductory course. They also provide us the opportunity to raise added, and sometimes more complex, issues.

We have also created an ftp site for this book that can be easily located from Wiley's home page. This provides tabulations of data for some of the examples and,

in some cases, technical details of their analyses. We also plan to post on this site a, hopefully very short, list of errors, thoughts that occur to us after submittal of the manuscript, and reader comments.

AN INVITATION

We hope that you will enjoy reading this book as much as we enjoyed writing it. In our continuing search for improvement (in possibly future editions), we invite and welcome your comments and suggestions. We can be reached at gerryhahn@yahoo.com and necipdoganaksoy@yahoo.com.

ACKNOWLEDGMENTS

In addition to contributing authors William Alexander, Tim Keyes, William Meeker and Robert Starbuck, and section author Colin McCulloch, we have asked various other knowledgeable people to comment critically on drafts of this book – and to set us straight, where needed. We were most fortunate to have received detailed and highly useful inputs on large parts of this manuscript from Ted Hardwicke, Roger Hoerl, Ron Kenett, Antonio Possolo and Gipsie Ranney. We also received very useful comments on individual chapters from Srinivas Bollapragada, Robert Bress, John Chakmakas, Veronica Czitrom, Ron Frank, Judy Hahn, Lynne Hare, Diane Lambert, Alson Look, Wayne Nelson, Paul Tobias, Scott Vander Wiel, Mark VanDeven and Emmanuel Yashchin. We also thank Kunter Akbay, Mark Bailey, James Cawse, Bill Cheetham, Christy Chuang-Stein, Michael Clayton, George Domingo, Harold Dyck, Don Ellington, Frank Forbes, Al Greene, Adrienne Hahn, Bea Hahn, Canan Hardwicke, Brent Harrington, Thomas Hochkirchen, Kati Illouz, Fred Immermann, Bob Keating, Mary Lanzerotti, Yan Liu, Eric Maass, Bill Makuch, Gary McDonald, Tom Menten, Ron Menton, Rob Mischler, Solon Morgan, Norm Moskowitz, Fanni Natanegara, Walter Offen, Don Olsson, Pete Parker, Frank Rockhold, Charles Sampson, Rasik Shah, Jeff Sheaffer, Vladimir Shper, Muzaffer Sutcu, Roy Tamura, Ben Verschueren, Greg Watson, Gene Wiggs, Tom Willemain, J.D. Williams, Will Yancey and Rui Zhang for their helpful comments and support.

We greatly appreciate the unwavering support and encouragement by Necip's managers at GE, Roger Hoerl and Rusty Irving. We also would like to thank Heather Haselkorn, Jackie Palmieri, Steve Quigley, and Susanne Steitz-Filler – our editors and their associates at Wiley – for their patience, encouragement and helpful comments.

We begin many sections with a quote. Some of these are taken from Gaither and Cavazos-Gaither (1996).

Finally, we thank our wives, Bea Hahn and Reyhan Doganaksoy, for their encouragement, strong support and remarkable perseverance over the years that we spent writing this book.

CONTENTS

PART I

SETTING THE STAGE

IN THIS part of the book we provide a brief review of the field and its many applications with introductory chapters on:

- Statistics: An Overview
- Statistics in Business and Industry

In these chapters, as well as the book as a whole, we aim to impart our excitement about statistics and its role in business and industry.