STATISTICS FOR BUSINESS AND ECONOMICS

SECOND EDITION

JOHN A. INGRAM
JOSEPH G. MONKS

STATISTICS FOR BUSINESS AND ECONOMICS

SECOND EDITION

JOHN A. INGRAM
Senior Statistician for Metromail Corporation,
a subsidiary of R. R. Donnelley & Sons, Inc.

JOSEPH G. MONKS
Gonzaga University

The Dryden Press
Harcourt Brace Jovanovich College Publishers
Fort Worth Philadelphia San Diego New York Orlando Austin San Antonio
Toronto Montreal London Sydney Tokyo

The Dryden Press Series in Management Science and Quantitative Methods

Forgionne
Quantitative Management

Freed
Basic Business Statistics

Gaither
Production and Operations Management, *Fifth Edition*

Hamburg
Statistical Analysis for Decision-Making, *Fifth Edition*

Ingram/Monks
Statistics for Business and Economics, *Second Edition*

Lapin
Statistics for Modern Business Decisions, *Fifth Edition*

Lapin
Quantitative Methods for Business Decisions with Cases

Lee
Introduction to Management Science, *Second Edition*

Mason, Lind, and Marchal
Statistics: An Introduction, *Third Edition*

Weiers
Introduction to Business Statistics

Acquisitions Editor: Scott Isenberg
Manuscript Editor: Cate DaPron
Production Editor: Pat Gonzalez
Art Editor: Louise Sandy-Karkoutli
Designer: Suzanne Montazer
Production Manager: Diane Southworth

ISBN: 0-15-583549-1

Library of Congress Catalog Card Number: 91-71628

Printed in the United States of America

A Brief Contents

Look for these symbols next to many of the most interesting, instructive Problems in *Statistics for Business and Economics*, Second Edition:

 deals with Sales/Marketing

 deals with Manufacturing/Production

 deals with Finance/Accounting/Economics

 deals with Government/Public Affairs/Public Policy

PREFACE

Statistics for Business and Economics, Second Edition, remains an introduction to the uses of statistics for understanding data, for the purpose of making meaningful business decisions. Its primary objective is to help students experience decision making based upon patterns observed from data. Since statistics can be used most effectively when data are well understood, a second objective of this book is to help students develop some skills for evaluating the reasonableness of data through data analysis. Careful editing, additions to concept explanations, and more examples and problems have shored up some important topics and thus have met yet another objective, which is to provide a clear and readable presentation of the fundamentals of business and economics statistics. Using computers is optional in *Statistics for Business and Economics*, but computers can be a highly effective tool in the use of statistics. So a fourth objective, available at the instructor's choosing, is to build computer skills with which to circumvent the otherwise time-consuming calculations required for obtaining some statistics.

An ultimate objective is for business students to become users, not simply learners, of statistics. *Statistics for Business and Economics*, Second Edition, offers students what would otherwise require several courses, and other practical experience: the combination of (1) directed study of fundamental concepts and (2) the building of skills for the practical use of statistics. When students learn statistics by studying the chapter and working the varied selection of regular Problems, and then understanding the Computer Applications and working the Computer Problems, they can become consumers of statistics. The authors believe that a coverage of this textbook that includes the Computer Applications and Computer Problems will provide students a reasonable background to become users of statistics in a business or economics work position, or it can be a stepping stone for more advanced (quantitative) studies.

WHAT IS NEW IN THIS EDITION?

Quite a lot is new! From our experience and that shared with us by others who have used the First Edition, we have made numerous changes and enhancements. In particular, to underscore its relevance in business, we have added new features in four general areas:

Data Analysis Experiencing and solving difficulties with data is real, even critical, in business work; it is essential that students — and professionals — understand the data before they begin analyzing a quantitative problem. So we have added, to an already generous number of Problems, many Problems that include 20 to 50 observations each. Further, some of these Problems require critical evaluation to assure that the data are both clean and appropriate for a proposed statistical analysis. Our treatment of data analysis includes the most current techniques — box plots; stem-and-leaf

displays; graphics, including Pareto charts, engineering diagrams, and flowcharts; data plots with residual analysis; and data frequency displays. Practical data analysis Problems are interspersed throughout the chapters.

Problem Solving for Real-World Applications Each chapter has (1) a Business Case, with questions, that illustrates how key chapter concepts can be used on the job, and (2) Statistics in Action: Challenge Problems, a special section that gives a new perspective to various chapter concepts. Both types of Problems require more thought than the section or chapter Problems. And because they come from our own research and from business journals, magazines, and government publications, the Business Cases and Challenge Problems reproduce actual on-the-job experiences.

Computer-Assisted Problem Solving This feature is optional (except in multiple regression), and the Computer Applications and Computer Problems are color-highlighted and placed at the end of the chapter to make them easy to find. Because Chapter 1 introduces the user-friendly Minitab software along with the data base, and each chapter continues to build usage skills, students have the opportunity to learn computer-assisted statistics problem solving without taking computer courses. The Computer Applications and Computer Problems provide instruction through examples that show program steps, explain program statements, and interpret the statistics outputs. Chapter 5 introduces the SPSS software, and thereafter the text continues to develop experience with both Minitab and SPSS. The Computer Applications and Computer Problems in Chapters 1-18 expose students to a high percentage of the concepts described in the *Minitab Student Edition Handbook*. The SPSS usage covers the same concepts, but is oriented to mainframe computers.

Fine-Tuned Fundamentals Except for adding a new chapter (15) on total quality control, we have left the topic content unchanged. However, emphasis has been added to descriptive statistics and data analysis, and estimation and hypothesis testing have been reorganized for more time-efficient coverage, with more flexibility in topic choices for a first course. The text material is ample to allow options for a second course as well. Here are the specific enhancements made to this Edition:

Chapter 1 The Computer Application and Computer Problems promote understanding of the data base, which is U.S. decennial census data that describe family membership, ages, education, and more.

Chapter 2, 3 Box plots and stem-and-leaf displays are introduced. Then the emphasis is on data analysis and data cleaning guides.

Chapter 5 The Poisson distribution coverage is expanded with another example and more background on using a probability table. New Minitab and SPSS computer setups help students calculate discrete variable probability distributions.

Chapters 6, 7 The Statistics in Action: Challenge Problems here provide more work on probability distributions.

Chapters 8, 9, 10 The t-distribution has been moved from Chapter 10 to Chapter 8 for estimation and to Chapter 9 for hypothesis testing. This gives an early distinction for the use of the Z- versus and the t-distribution, creating more options for a first course.

Chapter 11 Now we display the ANOVA assumptions and computing formulas for the 2-factor equal-numbers factorial design. Also new are examples of how to interpret experiment results when there is a significant interaction effect, plus more small data sets and questions on data analysis.

Chapter 12 Both the algebra solution (in the regular sections) and a computer approach (in the Computer Applications and Problems) are given for estimating a simple linear regression model. This allows a smooth transition to the multivariate procedures of multiple regression and the analysis of variance. Also, the First Edition Business Case has been reworked to improve its quality and meaning.

Chapter 13 Outliers, leverage points, and influential observations are discussed, thus expanding the analysis of residual data to include more discussion of data analysis.

Chapter 14 First Edition Chapters 14 and 15 are combined here to produce an integrated, cohesive coverage of time series and index numbers.

Chapter 15 This Total Quality Control chapter is all new. It emphasizes the continuous improvement of system and people processes for improved quality in the production of goods and services.

Chapter 17 Again, small data sets of 20 to 50 observations reinforce data analysis. This chapter, especially, shows the benefits of using computers — by including Problems asking for hand calculations, then doing the same calculations with statistical software.

LEARNING FEATURES IN EVERY CHAPTER

- Each chapter Introduction includes a pertinent, motivating illustration of statistics being used in business, followed by a statement of purpose for the chapter and an overview of the material that follows.
- Learning objectives describe 4–6 specific abilities students can expect to gain from studying the chapter.
- Examples illustrate fundamental statistics concepts in a business context. An interpretation of the computed results immediately follows each of the 200 Examples in the text.
- Problems are of three kinds. Section Problems within the chapters relate to specific concepts. End-of-chapter Problems reinforce the concepts and enhance analytical skills. Computer Problems, applied to real decision situations, make use of "live" data from the data base. There are 950 regular Problems and 120 more computer-assisted statistics Problems.
- Learning guides are procedures to guide students in solving problems that require more than a few steps. There are learning guides and equation summary tables in virtually every chapter.
- A content-based Summary reviews the key elements of the chapter.
- Key terms, italicized throughout the chapter, emphasize basic concepts. A list of Key Terms following the chapter Summary shows the pages on which each of approximately 300 key terms is defined.
- Business Cases use some of the authors' experiences and other business situations to show how statistics is used in specific decision circumstances.

These 18 experiences allow the student to assume the role of a decision maker; the questions that follow the Business Cases require some critical thinking.

- Statistics in Action: Challenge Problems include a brief description, the problem statement, and the data source for 78 carefully selected Problems from journals, magazines, and government publications. By answering the questions associated with these applications, students are introduced to various professional publications and become aware of the breadth of applications of statistical methods in business.
- The optional Computer Applications build on the textbook's 20,116-record data base and the scenario of a company that is marketing personal computers. (A sample of 100 of the data bank records, and the record layout, appears in Appendix A.) Computer Problems offer students the opportunity to generate computer-assisted solutions to approximately 120 decision questions.
- About 150 of the most interesting and instructive Problems are highlighted by icons:


Sales/Marketing


Manufacturing/Production


Finance/Accounting/Economics


Government/Public Affairs/Public Policy

- Numerous figures and tables clarify and condense the discussions of important concepts.
- At the end of the textbook are Appendices containing a brief data base, numerous statistical tables, math essentials for statistics, and the answers to the odd-numbered Problems. (The text Examples and Problems were worked using both the Student Edition of Minitab and SPSS, so students can expect these answers to give an accurate check of the results.)

CONTENT AND FLEXIBILITY

This work covers all areas normally included in the first course in business and economic statistics. The material in Chapters 1–9 provides a foundation for the business "specialty" topics of the remaining nine chapters. Chapters 1–3 concentrate on the terms and methods used to describe business data, and they emphasize data analysis techniques. Chapters 4–6 add more realism to the data environment by introducing structured measures for chance events in probabilities and probability distributions. Chapters 7, 8, and 9 form the basis for classical statistical inference. They are concerned with the use of sampling, estimation, and hypothesis tests in business situations. The remaining nine chapters introduce the most widely used extensions of statistical methods for business decisions. Even for a first course, this allows a selection of topics by the instructor.

Chapter 10 provides a bridge that builds from the Z- and t-statistic inference, including estimation and hypothesis testing in Chapters 8 and 9. Chapter 10 also

introduces the chi-square and *F*-distributions that are the foundation for Chapters 11 through 16. Analysis of variance and experimental design (Chapter 11) and chi-square tests (Chapter 16) cover techniques for testing the equality of means and proportions, respectively. Regression and correlation measures describe the nature and degree of association between two variables (Chapter 12) or for more than two variables (Chapter 13). This is extended to time series data and index numbers in Chapter 14. Chapter 15 introduces the procedures of total quality control. Nonparametrical statistics (Chapter 17) are generally not as ''powerful'' as statistics based on a known probability distribution, but they are gaining widespread use in economics, marketing, and management. Finally, Chapter 18 offers interested users the opportunity to extend some basic concepts of probability and statistics into the area of decision theory. This work includes a modern, innovative introduction to Bayesian decision theory, which has numerous applications in accounting and in marketing and operations management.

The text is designed to accommodate either a one-term or a two-term course, and the arrangement and organization of the chapters can be modified to suit a variety of usage patterns. Also, the more difficult material and Problems appear in optional starred sections. Alternative outlines for one- and two-term courses are given in the Instructor's Manual.

ADDITIONAL LEARNING MATERIALS

Several publications are available to augment the text:

- A Study Guide, developed by Professor A. Thomas Mason of the College of St. Thomas and Professor Dana Schumacher of Iowa State University, for students who seek additional insights and want more study problems.
- An Instructor's Manual containing teaching suggestions, solutions to all Problems in the textbook, and 60 overhead transparency masters.
- New to this edition, a Testbook (also available as a computerized Test Bank in IBM format) with over 500 test questions and their answers.
- Also available from the publisher, on computer disks, the 20,116-record data base and optional data base sample files of 500 records and 100 records.

ACKNOWLEDGMENTS

The authors extend heartfelt thanks to the many people who have contributed in developing, testing, and building this book. First, we appreciate the sure sense of direction and many helpful ideas provided by Scott Isenberg, our Acquisitions Editor. And we are grateful for the numerous suggestions and questions provided in the reviews submitted by Michael S. Broida, Miami University; Thomas S. Brown, Southwest Missouri State University; Mark Eakin, University of Texas at Arlington; Nicholas R. Farnum, California State University, Fullerton; Ralph C. Gamble, Fort Hays State University; David W. Gerbing, Portland State University; John O. Ifediora, The University of Wisconsin—Platteville; Thomas Johnson, North Carolina State University; Joseph F. Kearney, Davenport University; Eddie M. Lewis, The University of Southern Mississippi; Paul A. Thompson, The Ohio State University; James A. Xander, University of Central Florida; and Fike Zahroon, Moorhead State University.

We offer sincere thanks to those HBJ staff members who have patiently worked with us in the preparation of this book, including Cate DaPron, Manuscript Editor; Pat Gonzalez, Production Editor; Louise Sandy-Karkoutli, Art Editor; Suzanne Montazer, Designer; and Diane Southworth, Production Manager. We are indebted to

them for making this a clear presentation of the content; for producing the clean figures and tables; and for giving the final product a most pleasing appearance. But most of all we thank the HBJ team for making our shared work a pleasant, positive experience.

We express our appreciation to Molly Mostel Keys, who processed the solutions, charts, and graphs for the Instructor's Manual. Thanks also to graduate student Lisa Kinney for applying her considerable analytical skills to help organize materials, check problem solutions, and edit the drafts of the manuscript. In particular, we acknowledge the wholehearted support we received from Dean Bud Barnes of Gonzaga University and from Terry Coombes for arranging the personnel assistance and computer facilities to complete this project. Finally, we express sincere gratitude to our wives and families, who have very patiently stood by and encouraged us through this work.

John A. Ingrams
Joseph G. Monks

CONTENTS