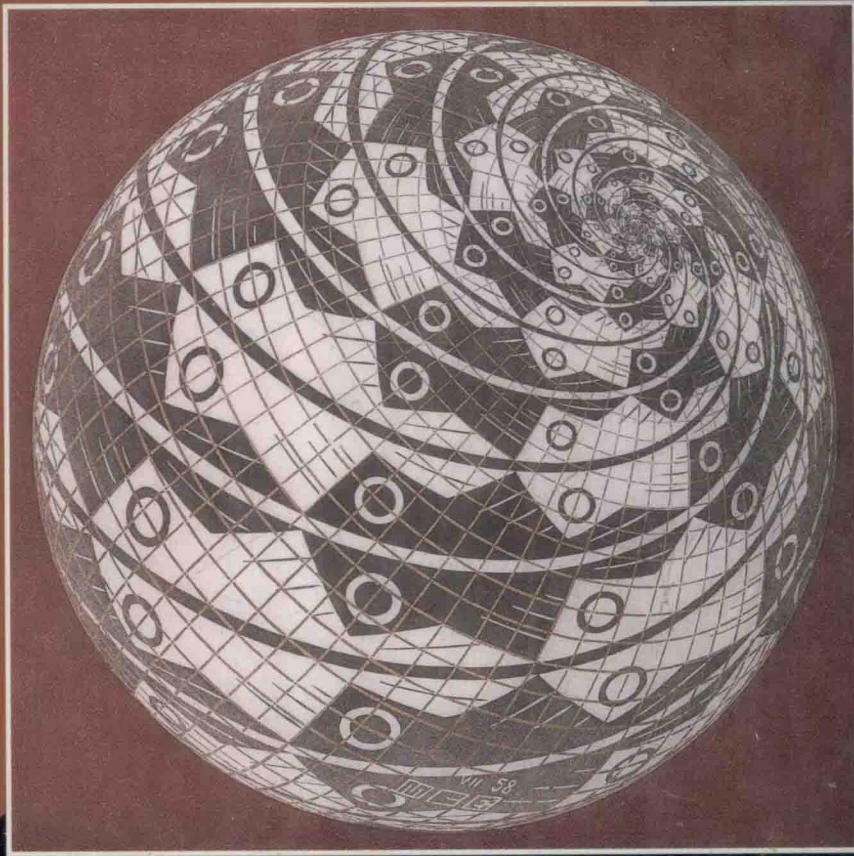


LAWRENCE L. LAPIN



# Statistics for Modern Business Decisions

SIXTH EDITION

# Statistics for Modern Business Decisions

---

SIXTH EDITION

**LAWRENCE L. LAPIN**  
*San Jose State 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

**Editor in Chief** Robert A. Pawlik  
**Acquisitions Editor** Scott Isenberg  
**Developmental Editor** Millicent Treloar  
**Project Editor** Jim Patterson  
**Production Manager** Alison J. Howell  
**Designer** Brian Salisbury  
**Permissions Editor** Van Strength

Cover © M.C. Escher/Cordon Art—Baarn—Holland

Copyright © 1993, 1990, 1987, 1982, 1978, 1973 by Harcourt Brace  
Jovanovich Inc.

All rights reserved. No part of this publication may be reproduced or  
transmitted in any form or by any means, electronic or mechanical, including  
photocopy, recording, or any information storage and retrieval system,  
without permission in writing from the publisher.

Requests for permission to make copies of any part of the work should be  
mailed to: Permissions Department, Harcourt Brace Jovanovich Publishers,  
8th Floor, Orlando, FL 32887.

*Address for Editorial Correspondence*

The Dryden Press, 301 Commerce Street, Suite 3700, Fort Worth, TX 76102

*Address for Orders*

The Dryden Press, 6277 Sea Harbor Drive, Orlando, FL 32887  
1-800-782-4479, or 1-800-433-0001 (in Florida)

ISBN: 0-15-500004-7

Library of Congress Catalog Number: 92-70669

Printed in the United States of America

3 4 5 6 7 8 9 0 1 2    0 6 9    9 8 7 6 5 4 3 2 1

The Dryden Press  
Harcourt Brace Jovanovich

**THE DRYDEN PRESS  
SERIES IN  
MANAGEMENT SCIENCE  
AND QUANTITATIVE  
METHODS**

**Forgionne**

*Quantitative Management*

**Freed**

*Basic Business Statistics*

**Gaither**

*Production and Operations Management*

Fifth Edition

**Glaskowsky, Hudson, and Ivie**

*Business Logistics*

Third Edition

**Hamburg**

*Statistical Analysis For Decision Making*

Fifth Edition

**Ingram and Monks**

*Statistics for Business and Economics*

Second Edition

**Lapin**

*Statistics for Modern Business Decisions*

Sixth Edition

**Lapin**

*Quantitative Methods for Business Decisions with Cases*

Fifth Edition

**Lee**

*Introduction to Management Science*

Second Edition

**Mason, Lind, and Marchal**

*Statistics: An Introduction*

Third Edition

**Miller and Wichern**

*Intermediate Business Statistics*

**Weiers**

*Introduction to Business Statistics*

**Zikmund**

*Business Research Methods*

Third Edition

**THE HBJ COLLEGE  
OUTLINE SERIES**

**Lapin**

*Business Statistics*

**Pentico**

*Management Science*

**Rothenberg**

*Probability and Statistics*

**Tanis**

*Statistics I: Descriptive Statistics and Probability*

**Tanis**

*Statistics II: Estimation and Tests of Hypothesis*

# PREFACE

---

In writing this introductory statistics book for students of business and economics, my overriding goal has been to enliven statistics, to make it more interesting, relevant, and easier to learn. It is no secret that today's student too often finds statistics boring and irrelevant and more difficult than necessary. Reflecting the evolution of statistical methodology, a *new goal* has been incorporated into this *sixth edition* that gives proper coverage of *exploratory data analysis*. This topic, along with descriptive and inferential statistics, is treated as essential to everyone's understanding of statistics.

To illustrate that statistics is really interesting and relevant, this book treats it as essentially a decision-making tool and includes many modern concepts and applications. All topics are introduced by carefully chosen examples that illustrate more than technical mathematical concepts. The stage is set, the motivation is provided, and the rationale is given as each new concept is presented. Accordingly, the importance of inferences is highlighted when a statistics professor compares the effectiveness of a new textbook with the book she currently uses. Testing for the equality of several proportions, an ad agency wishes to determine whether there are any differences in terms of reader recall among three different kinds of magazine advertisements. The fact that sampling is just one source of potential error is emphasized by detailing some of the blunders committed in taking the U.S. Decennial Census. Many of the examples and exercises are clearly related to present-day issues, such as health, conservation, and the environment. Several examples of each major area of business and economics—such as accounting, marketing, finance, production, forecasting, and consumer behavior—serve to richly illustrate the applications of statistics.

A course in high school algebra is the only background required. And although this book should prove more accessible than most, the relevant nature of its presentation has not been achieved at the cost of avoiding reputedly difficult material. Probability, hypothesis testing, and other more difficult topics receive generous explanation, often from several viewpoints. The reader is encouraged to rely more on intuition than on rote memory; less than the customary emphasis is placed on the mechanical and computational aspects of statistics. Purely mathematical symbolism has been minimized; for example, instead of the Boolean cup and bowl notation, the italicized *and* and *or* are used in describing probability concepts.

This sixth edition introduces several major improvements in presentation. The book's original character of being easy to use is enhanced by chapter opening lists titled "Before reading this chapter, make sure you understand" and "After reading this chapter, you will understand"; the former concisely itemizes prerequisite concepts that the reader should understand before reading; the latter poses major *questions* that the reader will want to answer while reading the chapter. The *answers* to the opening questions are given in the reformatted end-of-chapter *summary*. Most chapters have a "Real-Life Statistical Challenge" section, followed by questions, and a "Statistics in Practice" problem set, both of which feature *real data*. These

new course enrichment features are more challenging and less rigidly structured than the regular exercises and complement end-of-chapter *cases*. Computer applications are more prominent, with expanded coverage given to *Minitab*.

The sixth edition is the most extensively revised ever. New examples illustrate key concepts. Stock buying decisions give added flavor to the concept of variance, which serves as a *measure of risk* as well as a measure of dispersion. An expanded section on sampling and random variables employs *repeated* sampling experiments to give credence to the central limit theorem. *More diagrams* are used. *More real data* serve to introduce concepts. For example, baseball superstar performance statistics are used, not only to add perspective for understanding basic regression and correlation concepts, but also to make statistics *more interesting and relevant*.

To facilitate these changes, some chapters have been revamped. An expanded Chapter 1, “About Statistics,” includes coverage of the basic ideas of data analysis. The descriptive statistics in Chapter 2 includes many *more data display types*. Chapter 3, which presents statistical measures (mean, etc.), has been *streamlined* to facilitate data analysis as well as traditional statistics. Chapter 5 now has a shorter and dramatically *simplified probability* discussion that gives only the essentials. (No probability topics have been lost in the shuffle; the more difficult material has been relocated later in the book.) Time-series in Chapter 12 now includes *seasonal* exponential smoothing. A *model-building* segment has been added to multiple regression (Chapter 11), and a discussion of *stepwise multiple regression* procedures has been included.

The sixth edition has been reorganized by grouping the chapters into coherent parts.

Part I Basic Statistical Concepts

Part II Drawing Conclusions from Samples: Inferential Statistics

Part III Important Business Applications of Statistics

Part IV Further Topics in Inferential Statistics

Part V Probability Applications for Business Analysis

Part VI Decision Analysis

Parts I and II provide the key concepts for introductory courses. Part III houses the important business applications—time series, quality control, and index numbers—which now appear *earlier* in the book. Advanced inference topics are positioned in Part IV, facilitating the picking and choosing of course materials. To that end, further probability topics are now grouped into Part V, conveniently arranged so that instructors can separate probability material, making it easier to *customize* and *enrich* courses. The more challenging counting methods and Bayes’ theorem are discussed here in the new Chapter 20. Chapter 21 covers subjective probability, a topic of broad interest whose relocation should make it more accessible. Chapter 22 presents further probability distributions, now separated from goodness-of-fit testing in Chapter 23. As in previous editions, decision theory appears at the back of the book, in Part VI, a convenient placement for the many instructors who use some of those topics in a second statistics course. This segment includes new material on Bayesian sampling with the mean (Chapter 28) and utility theory (Chapter 29). *Users of earlier editions will find a detailed synopsis of the book’s major changes in the Instructor’s Manual.*

Many new problems have been added, and a number of the original ones have been updated or modified. Most sections within chapters have their own problem sets, permitting the student to relate the questions easily to the concepts just covered. This arrangement also gives the instructor flexibility in picking topics within a chapter. All problems are graded, so that each set begins with easy exercises and



increases in difficulty. As a further improvement, much of the statistical jargon and notation has been simplified. All of these changes should make the book easier to use and to teach from.

The book has been thoroughly class tested in a variety of circumstances and courses in many colleges and universities. The experience of hundreds of instructors has been drawn upon in writing this sixth edition.

The modern flavor of the book is enhanced by the expanded computer coverage. Great care has been taken not to tie this book too closely to any particular software or computer. It can still be used *without* computers, and all passages involving computers are primarily of an enrichment nature and are strictly *optional*. The exercises have been expanded to include *optional* computer problems having data sets too large to be reasonably solved by hand.

An examination of the table of contents reveals that there is much to choose from in this book. The chapters have been constructed to make it easy for the instructor to design a course to fit individual needs. Classical statistics has not been mixed with statistical decision theory—this book may be used with either emphasis. Many modern texts supplant classical statistics; both the old and the new are available here. Overall, the presentation is familiar except for the inclusion of several topics omitted from most texts. Chapter 15 considers two-sample inferences. Chapters 16, 17, and 18 discuss analysis of variance and chi-square applications. Chapter 17 includes several probability distributions—the hypergeometric, Poisson, exponential, and uniform. These may be conveniently omitted or incorporated in a course without loss of continuity. Chapter 19 contains some nonparametric statistics most useful for business applications. The Bayesian decision-making procedures of Chapters 24–29 emphasize decision trees; much of the symbology and terminology of decision theory is avoided to allow a simpler and more pragmatic presentation. The chapters on so-called Bayesian methods have been used primarily to extend statistics to areas where classical procedures have proved inadequate in analyzing decisions under uncertainty.

A glossary of statistical symbols is provided on the endpapers for easy reference. Abbreviated answers to all even-numbered exercises are included in the back of the book. Complete solutions to all exercises are available in the Instructor's Manual, and nearly 200 additional exercises and more than 600 examination questions and their solutions are available in a Testbook. The Instructor's Manual also provides teaching suggestions and hints on structuring courses. A *Study Guide* containing more than 200 solved problems is also available for student use as a workbook.

Also available to accompany this book is the *Guide to EasyStat*, a computer manual that incorporates a complete software package called *EasyStat*, all included on a diskette that comes inside every manual. *EasyStat* is a user-friendly program for any IBM PC-compatible system. The computer manual is keyed to the text and contains its own detailed examples and hundreds of problems. A special feature of *EasyStat* is a master data set comprising U.S. Decennial data for 1,000 urban employed homeowners. Students can select their own random samples from 14 different categories and analyze them separately. Class results can be pooled to illustrate concepts of sampling error.

The new end-of-chapter features, “Real-Life Statistical Challenge” and “Statistics in Practice,” were written by my colleague, Jerome Burstein, of San Jose State University. I wish to thank Jerry for helping to make my book more relevant, interesting, and functional. I am greatly indebted to the many people who have assisted me in preparing this book. Special thanks go to Janet Anaya of San Jose State

University, who carefully checked the manuscript for accuracy. I also wish to thank my colleagues whose comments were invaluable in setting the tone and the reviewers of this edition: Raymond J. Ballard, East Texas State University; Roger Even Bove, West Chester University; Douglas P. Dotterweich, East Tennessee State University; Jim Knudsen, Creighton University; and Richard M. Smith, Bryant College.

Finally, thanks go to the book team at The Dryden Press: Scott Isenberg, acquisitions editor; Millicent Treloar, developmental editor; Jim Patterson, project editor; Alison J. Howell, production manager; and Brian Salisbury, designer.

I am deeply grateful to my students, who over many years of debugging the book helped identify the problems a reader might face.

*Lawrence L. Lapin*



# CONTENTS

Preface     vii

## **PART I   BASIC STATISTICAL CONCEPTS     1**

### **1   ABOUT STATISTICS     2**

- 1-1   The Meaning of Statistics     3  
      The Role of Statistics   4 / Types of Statistics: Descriptive, Inferential,  
      and Exploratory   5 / Exercises   7
- 1-2   Statistical Data     7  
      Classifications for Data and Variables   7 / Types of Quantitative  
      Data   8 / Exercises   9
- 1-3   The Population and the Sample     9  
      Distinguishing Between the Data Set, Population, and Sample   10 /  
      Elementary Units   11 / Working Population and the Frame   12 /  
      Qualitative and Quantitative Populations   12 / Deductive and  
      Inductive Statistics   13 / Statistical Error   15 / Exercises   15  
      **Summary   16**  
      **Real-Life Statistical Challenge   17**  
      **Review Exercises   20**  
      **Statistics in Practice   21**

### **2   DESCRIBING AND DISPLAYING STATISTICAL DATA     22**

- 2-1   The Frequency Distribution     23  
      Finding a Meaningful Pattern for the Data   23 / Graphical Displays:  
      The Histogram   24 / Graphical Displays: The Frequency Polygon   25 /  
      Describing a Population: The Frequency Curve   26 / Descriptive  
      Analysis   27 / Constructing a Frequency Distribution: Number and  
      Width of Class Intervals   28 / Stem-and-Leaf Plots   30 /  
      Accommodating Extreme Values   31 / Computer-Assisted  
      Construction   32 / Qualitative Frequency Distributions   32 / The Pie  
      Chart   33 / Exercises   36
- 2-2   Relative and Cumulative Frequency Distributions     39  
      Relative Frequency Distributions   39 / Cumulative Frequency  
      Distributions   42 / Exercises   43
- 2-3   Common Forms of the Frequency Distribution     45  
      Exercises   47
- 2-4   Displaying Data in Multiple Dimensions     48  
      Quantitative Data Displays—The Scatter Diagram   48 / Qualitative  
      Data Displays—The Cross Tabulation   49 / Higher Dimensional Data  
      50 / Exercises   50

2-5	Special Data Displays	51
	The Box Plot	51 / The Control Chart
		53 / Exercises
	<b>Summary</b>	<b>54</b>
	<b>Real-Life Statistical Challenge</b>	<b>55</b>
	<b>Review Exercises</b>	<b>58</b>
	<b>Statistics in Practice</b>	<b>60</b>
	<b>Case: Ingrid's Hallmark Shop I</b>	<b>62</b>

### **3 SUMMARY DESCRIPTIVE MEASURES 64**

3-1	The Arithmetic Measures	65
	Symbolic Expressions for Calculating the Arithmetic Mean	65 / The Population and Sample Mean
		66 / Using a Computer to Calculate the Mean
		66 / Decision Making with the Mean
		67 / Approximating the Mean Using Grouped Data
		68 / Exercises
		69
3-2	The Median and the Mode	72
	The Median	72 / The Median Contrasted with the Mean
		72 / The Mode
		73 / Finding the Median and Mode From a Stem-and-Leaf Plot
		74 / Positional Comparison of Measures: Skewed Distributions
		74 / Bimodal Distributions
		76 / Exercises
		76
3-3	Percentiles, Fractiles, and Quartiles	79
	Exercises	84
3-4	Measuring Variability	86
	Importance of Variability	86 / Distance Measures of Dispersion
		88 / The Interquartile Range
		88 / The Box Plot and Quartiles
		90 / Measures of Average Deviation
		90 / The Variance
		91 / The Sample and Population Variance
		92 / The Standard Deviation
		92 / Using a Computer to Calculate the Standard Deviation
		93 / Shortcut Calculations for the Variance and Standard Deviation
		94 / A Practical Use for the Standard Deviation
		96 / Exercises
		98
3-5	The Proportion	100
	Exercises	101
	<b>Summary</b>	<b>102</b>
	<b>Real-Life Statistical Challenge</b>	<b>104</b>
	<b>Review Exercises</b>	<b>107</b>
	<b>Statistics in Practice</b>	<b>110</b>
	<b>Case: Ingrid's Hallmark Shop II</b>	<b>111</b>

### **4 THE STATISTICAL SAMPLING STUDY 114**

4-1	The Need for Samples	115
	The Economic Advantages of Using a Sample	115 / The Time Factor
		115 / The Very Large Population
		116 / Partly Inaccessible Populations
		116 / The Destructive Nature of the Observation
		116 / Accuracy and Sampling
		117 / Exercises
		117
4-2	Designing and Conducting a Sampling Study	118
	The Importance of Planning	118 / Data Collection
		120 / Data Analysis and Conclusions
		120
4-3	Bias and Error in Sampling	120
	Sampling Error	120 / Sampling Bias
		121 / Nonsampling Error
		122 / Exercises
		124

4-4	Selecting the Sample	125
	The Convenience Sample	125 / The Judgment Sample 126 / The Random Sample 126 / Sample Selection Using Random Numbers 127 / Types of Random Samples 129 / Exercises 131
4-5	Selecting Statistical Procedures	132
	Summary	135
	Real-Life Statistical Challenge	136
	Review Exercises	139
	Statistics in Practice	139
	Case: Boomville	141
<b>5</b>	<b>PROBABILITY</b>	<b>145</b>
5-1	Basic Probability Concepts	146
	Probability as Long-Run Frequency	146 / The Random Experiment and Its Elementary Events 146 / Complicating Issues 148 / Objective and Subjective Probabilities 148 / The Law of Large Numbers 149 / Exercises 149
5-2	Probabilities for Composite Events	150
	The Sample Space, Composite Events, and Event Sets	150 / The Count-and-Divide Method for Computing Probabilities 152 / Probability Estimates 152 / Certain and Impossible Events 154 / Alternative Expressions of Probability 154 / Probability and Samples 154 / Exercises 155
5-3	Joint Probability and the Multiplication Law	156
	The Joint Probability Table	156 / Mutually Exclusive and Collectively Exhaustive Events 157 / Joint Events and Probabilities 157 / Marginal Probabilities 157 / The Multiplication Law for Finding "And" Probabilities 158 / Some Advice and Warnings About the Multiplication Law 159 / Joint Probabilities Involving More Than Two Events 160 / Probabilities When Elementary Events are not Equally Likely 160 / Exercises 161
5-4	Finding Probabilities Using the Addition Law	162
	The Addition Law for Finding "Or" Probabilities	163 / Some Advice and Warning About the Addition Law 163 / Mutually Exclusive and Collectively Exhaustive Events 165 / Application to Complementary Events 165 / Exercises 166
5-5	Statistical Independence	167
	A Definition of Statistical Independence	167 / A Basic Test for Independence Between Events 167 / Commonly Encountered Instances of Statistical Independence 168 / Independent Events and the Multiplication Law 169 / Finding Joint Probabilities For Dependent Events 169 / Constructing a Joint Probability Table Without a Cross Tabulation 170 / Exercises 171
5-6	Conditional Probability and the General Multiplication Law	171
	Computing Conditional Probabilities	172 / Conditional Probability and Statistical Independence 176 / The General Multiplication Law 176 / Constructing a Joint Probability Table with the Assistance of the General Multiplication Law 178 / Exercises 179

5-7	Probability Trees and Further Laws	181
	The Probability Tree Diagram	181 / Multiplication Law for Several Events 183 / The General Addition Law 184 / Common Errors in Applying the Laws of Probability 185 / Exercises 186
	<b>Summary</b>	<b>188</b>
	<b>Real-Life Statistical Challenge</b>	<b>190</b>
	<b>Review Exercises</b>	<b>192</b>
	<b>Statistics in Practice</b>	<b>197</b>
	<b>Case: The Three Marketeers</b>	<b>198</b>

## **PART II DRAWING CONCLUSIONS FROM SAMPLES: INFERENCE STATISTICS 201**

### **6 PROBABILITY DISTRIBUTIONS, EXPECTED VALUE, AND SAMPLING 202**

6-1	Random Variables and Probability Distributions	203
	The Random Variable	203 / The Probability Distribution 203 / Finding the Probability Distribution 206 / Probability Trees and Sampling 208 / Discrete and Continuous Random Variables 212 / Exercises 213
6-2	Expected Value and Variance	214
	The Expected Value of a Random Variable	214 / The Variance of a Random Variable 215 / Expected Value and Variance in Decision Making 216 / Exercises 217
6-3	Population Parameters and Sampling	219
	Population Parameters	219 / Probability for a Randomly Selected Observation 220 / Exercises 221
6-4	The Sampling Distribution of the Mean	222
	Sampling with and without Replacement	224 / An Empirical Approximation of the Sampling Distribution of the Mean 225 / Some Theoretical Properties of the Sampling Distribution of the Mean 228 / Exercises 230
6-5	Binomial Probabilities: The Sampling Distribution of the Proportion	230
	The Bernoulli Process	232 / The Number of Combinations 232 / The Binomial Formula 234 / Important Properties of the Binomial Distribution 236 / The Cumulative Probability Distribution 238 / Using Binomial Probability Tables 240 / Expected Value and Variance of a Binomial Random Variable 243 / The Sampling Distribution of the Proportion 243 / Exercises 245
6-6	Continuous Probability Distributions	248
	Smoothed Curve Approximation	249 / Probability Density Function 250 / Cumulative Probability Distribution 251 / The Expected Value and the Variance 252
	<b>Summary</b>	<b>252</b>
	<b>Real-Life Statistical Challenge</b>	<b>254</b>
	<b>Review Exercises</b>	<b>256</b>

**Statistics in Practice 259**

**Case: AlphaComp 260**

## **7 THE NORMAL DISTRIBUTION 263**

7-1 Characteristics of the Normal Distribution 264

7-2 Finding Areas Under the Normal Curve 267

Using the Normal Curve Table 269 / Cumulative Probabilities and Percentiles 273 / The Standard Normal Random Variable 274 / Additional Remarks 276 / Exercises 276

7-3 Sampling Distribution of the Sample Mean for a Normal Population 277

The Role of the Standard Error 279 / Exercises 282

7-4 Sampling Distribution of  $\bar{X}$  When the Population Is Not Normal 283

A Multiple-Sample Experiment 283 / The Central Limit Theorem 285 / Exercises 290

7-5 Sampling Distributions of  $P$  and the Normal Approximation 291

Advantages of Approximating the Binomial Distribution 291 / The Normal Distribution as an Approximation 292 / An Application of the Normal Approximation to Acceptance Sampling 297 / Exercises 298

**Summary 299**

**Real-Life Statistical Challenge 300**

**Review Exercises 302**

**Statistics in Practice 303**

**Case: MBA Income and Stature 304**

7-6 Optional Topic: Sampling Distribution of  $\bar{X}$  When the Population Is Small 307

Finite Population Correction Factor 308 / Optional Exercises 309

## **8 STATISTICAL ESTIMATION 311**

8-1 Estimators and Estimates 312

The Estimation Process 312 / Credibility and Precision in Estimation 314 / Choosing an Estimator 314 / Criteria for Statistics Used as Estimators 314 / Commonly Used Estimators 316 / Exercises 318

8-2 Interval Estimates of the Mean When  $\sigma$  Is Known 319

Confidence and Meaning of the Interval Estimate 321 / Constructing the Confidence Interval 321 / Features Desired in a Confidence Interval 323 / Computer-Generated Confidence Intervals 324 / Exercises 324

8-3 Interval Estimates of the Mean When  $\sigma$  Is Unknown 326

The Student  $t$  distribution 326 / Constructing the Confidence Interval 328 / Computer-Generated Confidence Intervals 330 / Confidence Intervals When  $n$  Is Large 330 / Exercises 332

8-4 Interval Estimates of the Population Proportion 334

Exercises 335

8-5	Choosing the Sample Size and Selecting the Estimator	336
	Error and Reliability	336 / Steps for Finding the Required Sample Size to Estimate the Mean 338 / Three Influences on Sample Size 340 / Finding a Planning Estimate of $\sigma$ 341 / Steps for Finding the Required Sample Size to Estimate the Proportion 343 / Choosing the Estimator 344 / Reliability Versus Confidence and Tolerable Error Versus Precision 346 / Exercises 346
	<b>Summary</b>	<b>348</b>
	<b>Real-Life Statistical Challenge</b>	<b>350</b>
	<b>Review Exercises</b>	<b>351</b>
	<b>Statistics in Practice</b>	<b>353</b>
	<b>Case: Brown and Becker's Budget</b>	<b>354</b>

## **9 HYPOTHESIS TESTING 357**

9-1	Basic Concepts of Hypothesis Testing: Testing a New Drug	358
	The Null and Alternative Hypotheses	359 / Making the Decision 360 / Finding the Error Probabilities 362 / Choosing the Decision Rule 363 / Making the Decision 364 / Formulating Hypotheses 364 / Exercises 365
9-2	Testing the Mean	368
	The Hypothesis-Testing Steps	368 / Upper-Tailed Test 372 / Lower-Tailed Tests 376 / Two-Sided Tests 379 / Hypothesis Testing and Confidence Intervals 382 / Summary of Testing the Mean 382 / Variations in Hypothesis-Testing Procedures 382 / Exercises 385
9-3	Testing the Proportion	391
	Using $P$ as the Test Statistic	391 / Exercises 394
9-4	Selecting the Test	395
	Some Important Questions	395 / The Power Curve 395 / Efficiency and Power 396
9-5	Limitations of Hypothesis-Testing Procedures	396
	<b>Summary</b>	<b>398</b>
	<b>Real-Life Statistical Challenge</b>	<b>399</b>
	<b>Review Exercises</b>	<b>400</b>
	<b>Statistics in Practice</b>	<b>403</b>
	<b>Case: SynerGentex</b>	<b>403</b>

## **10 REGRESSION AND CORRELATION 406**

10-1	Regression Analysis	407
	The Scatter Diagram	408 / The Data and the Regression Equation 408 / Some Characteristics of the Regression Line 411 / Fitting a Straight Line to the Data 412 / Exercises 412
10-2	Correlation Analysis	413
	The Correlation Coefficient	417 / Computing the Correlation Coefficient 418 / Exercises 421
10-3	Finding the Regression Equation	423

- The Method of Least Squares 423 / Illustration of the Method 425 / Meaning and Use of the Regression Line 426 / Measuring Variability in Results 427 / Computer-Assisted Regression Analysis 430 / Exercises 432
- 10-4 Assumptions and Properties of Linear Regression Analysis 435  
 Assumptions of Linear Regression Analysis 435 / Sampling and Regression Analysis 436 / Estimating the True Regression Equation 438 / Inferences Regarding Regression Coefficients 439 / Exercises 439
- 10-5 Predictions and Statistical Inferences Using the Regression Line 440  
 Predictions Using the Regression Equation 440 / Prediction Intervals for the Conditional Mean 441 / Prediction Intervals for an Individual Value of  $Y$  Given  $X$  444 / Computer-Generated Interval Estimates 444 / Inferences Regarding the Slope of the Regression Line 445 / Exercises 445
- 10-6 Assessing the Quality of Regression Analysis 446  
 The Coefficient of Determination 446 / Appropriateness of the Model: Residual Analysis 451 / Exercises 454
- 10-7 Common Pitfalls and Limitations of Regression and Correlation Analysis 456  
 Dangers of Extrapolation in Regression Analysis 456 / Relevancy of Past Data 457 / Correlation and Causality 457
- 10-8 Nonlinear Regression Analysis 458  
 Solving by Transformation of Variables 460 / Fitting a Polynomial 460 / Exercises 461  
**Summary 461**  
**Real-Life Statistical Challenge 463**  
**Review Exercises 464**  
**Statistics in Practice 466**  
**Case: La Boutique Fantastique 468**
- 10-9 Optional Topic: Inferences Regarding Regression Coefficients 469  
 Confidence Interval Estimate of  $B$  469 / Testing Hypotheses About  $B$  470 / Using  $B$  to Make Statistical Inferences About  $p$  471 / Computer-Assisted Inferences About Regression Coefficients 472 / Optional Exercises 472

## **11 MULTIPLE REGRESSION AND CORRELATION 474**

- 11-1 Linear Multiple Regression Involving Three Variables 475  
 Regression in Three Dimensions 475
- 11-2 Multiple Regression Using the Method of Least Squares 477  
 Illustration: Predicting Supermarket Profits 478 / Advantages of Multiple Regression 480 / Residuals and the Standard Error of the Estimate 482 / Assumptions of Multiple Regression 484 /



	Challenges and Pitfalls of Multiple Regression Analysis	484 / Exercises	488
11-3	Multiple Regression: Computer Applications		490
	Computer-Assisted Multiple Regression Analysis		491
	/ Exercises		493
11-4	Inferences in Regression Analysis		496
	Prediction Intervals in Multiple Regression		496 / Inferences Regarding Regression Coefficients
			498 / Exercises
11-5	Multiple Correlation		500
	Coefficient of Multiple Determination		500 / Partial Correlation
			502 / Exercises
11-6	Finding a Predictive Regression Model		506
	Goals for a Predictive Model		506 / Searching for the Best Predictors: All Regressions
			507 / Stepwise Regression
			507 / Illustration: Performance Predictors for Baseball Batter Superstar Salary
			509 / Fine-Tuning the Model I: Eliminating Outliers
			511 / Kinds of Stepwise Regression
			512 / Stepwise Regression with a Computer
			512 / Selecting Screening Parameters
			513 / Fine-Tuning the Model II: Finding a Regression Equation that Makes Sense
			516 / Exercises
11-7	Dummy Variable Techniques		518
	Using a Dummy Variable		519 / Using a Dummy Variable with Time Series
			522 / Using a Dummy Variable in Interactive Multiple Regression
			523 / Exercises
	Summary		528
	Real-Life Statistical Challenge		530
	Review Exercises		532
	Statistics in Practice		537
	Case: Adventures in Regression Land		538
11-8	Optional Topic: Polynomial Regression		541
	Optional Exercises		544

## **PART III IMPORTANT BUSINESS APPLICATIONS OF STATISTICS 547**

### **12 FORECASTING WITH TIME SERIES 548**

12-1	The Time Series and Its Components		549
12-2	The Classical Time-Series Model		550
	Illustration: A Time Series for Stereo Speaker Sales		550 / Exercises
			555
12-3	Analysis of Secular Trend		557
	Describing Trend		557 / Determining Linear Trend Using Least Squares
			558 / Modifying Trend for Periods Shorter Than One Year
			559 / Forecasting Sales Using a Trend Line
			561 / Nonlinear Trend: Exponential Trend Curve
			563 / Exercises
			568
12-4	Forecasting with Moving Averages and Seasonal Indexes		570

	Ratio-to-Moving-Average Method	570	/ Finding the Seasonal Indexes	572	/ Deseasonalized Data	573	/ Making the Forecast	574	/ Exercises	574
12-5	Identifying Cycles and Irregular Fluctuation	577								
12-6	Exponential Smoothing	577								
	Forecasting Errors	578	/ Two-Parameter Exponential Smoothing	579	/ Computer Applications	582	/ Seasonal Exponential Smoothing with Three Parameters	583	/ Fine-Tuning Exponential-Smoothing Parameters	589
	Further Exponential-Smoothing Procedures	590	/ Exercises	591						
	<b>Summary</b>	593								
	<b>Real-Life Statistical Challenge</b>	594								
	<b>Review Exercises</b>	595								
	<b>Statistics in Practice</b>	598								
	<b>Case: BugOff Chemical Company</b>	601								

### **13 STATISTICAL QUALITY CONTROL 603**

13-1	The Control Chart for Qualitative Data	604								
	Establishing Control Limits for the Proportion	605	/ Applying the Control Chart	607	/ Further Remarks	609	/ Exercises	609		
13-2	The Control Chart for Quantitative Data	610								
	The Control Chart for the Sample Mean	612	/ The Control Chart for the Sample Range	614	/ Implementing Statistical Control	615	/ Exercises	615		
13-3	Acceptance Sampling	617								
	Basic Concepts of Acceptance Sampling	617	/ Producer's and Consumer's Risk	618	/ Selecting the Decision Rule	618	/ Sequential Sampling	619	/ Exercises	620
	<b>Summary</b>	621								
	<b>Real-Life Statistical Challenge</b>	622								
	<b>Review Exercises</b>	624								
	<b>Case: Billings, Kidd, and Hickock</b>	625								

### **14 INDEX NUMBERS 627**

14-1	Price Indexes	628								
14-2	Aggregate Price Indexes	630								
	Exercises	633								
14-3	The Consumer Price Index	635								
	Exercises	637								
14-4	Deflating Time Series Using Index Numbers	637								
	Exercises	639								
	<b>Summary</b>	639								
	<b>Real-Life Statistical Challenge</b>	641								
	<b>Review Exercises</b>	642								
	<b>Statistics in Practice</b>	643								
	<b>Case: The Variety Galore Stores</b>	645								