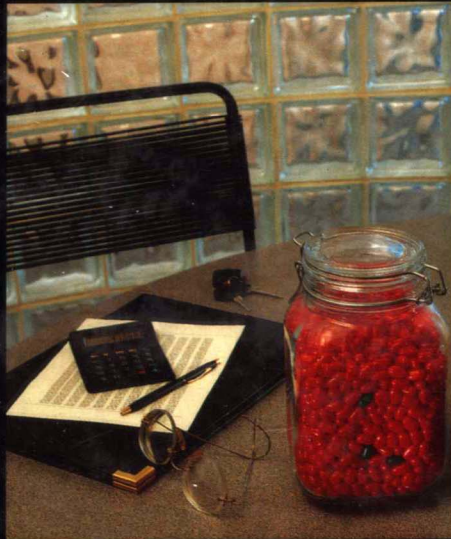

BUSINESS STATISTICS

TEXT ■ CASES ■ SOFTWARE



IBM® PC VERSION

HALL
ADELMAN

BUSINESS

STATISTICS

TEXT ■ CASES ■ SOFTWARE

OWEN P. HALL, JR.
HARVEY E. ADELMAN
*Both of
Pepperdine University*

IRWIN

Homewood, IL 60430
Boston, MA 02116

IBM®PC and IBM®PS/2® are a registered trademarks of International Business Machines Corporation.

MST™ DOS is a trademark of Microsoft Corporation.

Richard D. Irwin, Inc., makes no warranties, either expressed or implied, regarding the enclosed computer software package, its merchantability or its fitness for any particular purpose. The exclusion of implied warranties is not permitted by some states. The exclusion may not apply to you. This warranty provides you with specific legal rights. There may be other rights that you may have which may vary from state to state.

© RICHARD D. IRWIN, INC., 1991

All rights reserved. No part of this publication may be reproduced, stored in a retrieval system, or transmitted, in any form or by any means, electronic, mechanical, photocopying, recording, or otherwise, without the prior written permission of the publisher.

Senior sponsoring editor: Richard T. Hercher, Jr.
Project editor: Karen Smith
Production manager: Bette K. Ittersagen
Cover photographer: Russell Phillips
Text illustrators: Carlisle Communications, Ltd./Benoit Design
Compositor: Progressive Typographers, Inc.
Typeface: 10/12 Times Roman
Printer: R. R. Donnelley & Sons Company

Library of Congress Cataloging-in-Publication Data

Hall, Owen P.

Business statistics: text, cases, and software / Owen P. Hall,

Jr., Harvey E. Adelman.

p. cm.

Includes bibliographical references and index.

ISBN 0-256-06089-4 (PC version) 0-256-10056-X (PS/2 version)

1. Commercial statistics—Data processing. 2. Statistics—Data processing. I. Adelman, Harvey E. II. Title

HF1017.H23 1991

519.5'024658 —dc20

90-38294

Printed in the United States of America

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

Preface

Statistical analysis has become an increasingly important management tool throughout all levels of business and government. The glowing success of the Japanese in effectively penetrating the international marketplace with products of high quality and high reliability can be directly attributed to their emphasis on statistical quality control. The need for a better understanding of basic statistical principles will continue to grow in concert with the advent of the information age. The primary purpose of this text is to provide the student with such an understanding using the latest developments in computer-based courseware (CBS).

A number of different approaches have been used in the preparation of statistical textbooks. They have ranged from the “theoretical” to the “intuitive.” For the most part, however, the primary focus of these texts has been on solving simple problems using hand solution methods. The authors believe that this approach is inconsistent with the needs of modern management practice. Instead, we think the primary focus should be on problem formulation and results interpretation. The role of performing the computations should be left to the computer. The widespread proliferation of microcomputers on college campuses provides an effective vehicle for implementing this pedagogical strategy. Although some texts do acknowledge the usefulness of computers in solving statistical problems, few have modified their basic approach to incorporate the full potential of computer-based analysis. As an instructional aid, however, most of the technical chapters in these books contain an appendix that presents the basic analytical formulas along with appropriate examples.

The most important challenge in statistics, however, is not in performing the computations (either by hand or by machine) but in collecting the data and properly interpreting the computational results. Normally, the primary issue facing the business manager is not in developing an answer but in asking and formulating the proper question. Accordingly, a major focus of *this* text is to provide a contextual framework to aid the student in understanding the questioning process and to provide answers through computer-based analysis.

The modern manager uses statistics in three basic ways:

1. Collecting and processing data (i.e., descriptive statistics).
2. Estimating population characteristics from the collected data (i.e., statistical inference).
3. Developing relationships from the processed data (i.e., statistical forecasting).

In each application, the manager must relate the questions that have been asked to the data collected and the statistical analysis performed. This text is designed to assist the student in developing insights into the application of statistics in modern management practice through the application of real-world business cases.

TOPICS COVERED

The topics covered in the 15 chapters of this book are similar to those found in most first-year statistics texts. Within each chapter, however, the primary emphasis is on *problem formulation* and on *interpreting the results*. Simple graphical models are used to illustrate the basic principles before expanding to more realistic and interesting business management problems. This text features a wide array of statistical quality-control applications. Additionally, a number of internally based cases and examples are presented.

This text introduces the most frequently used statistical methods via specific business applications. Each subject area is introduced by describing examples of its use in a real organization. Formulation is emphasized, and each chapter contains examples of formulated problems and at least one formulated business case. The text contains over 800 problems and approximately 40 cases. The same basic outline, which is fully explained in chapter 1, is used in each chapter.

This text has been designed to provide the instructor with considerable flexibility in terms of selecting topics to meet specific course requirements. With several exceptions each chapter stands by itself, so the course can be taught with topics introduced in the order preferred by the instructor. The variety and extent of the problem sets provides the instructor with considerable flexibility in preparing a course ranging in length from one quarter to two semesters.

SUPPORTING MATERIALS

Accompanying this text is a complete package of support materials. These include:

- Computerized Business Statistics (CBS) Software Package.
- Instructor's Manual.

- Financial Data on Fortune 500 Firms and Key Economic Data.
- Solutions to Problems and Cases.

The financial and economic data and the solutions to problems and cases are available on data diskette.

ACKNOWLEDGMENTS

The authors would like to acknowledge the following individuals for their help and support in the creation of this text and the software *Computerized Business Statistics*.

Amir Aczel, *Bentley College*
 Randy J. Anderson, *California State University, Fresno*
 Charles Branyan, *Memphis State University*
 Anthony A. Casey, *University of Dayton*
 Gilbert Coleman, *University of Nevada, Reno*
 Les Dlabay, *Lake Forest College*
 Satyendra Dutt, *Delaware State College*
 David L. Eldredge, *Murray State University*
 Stewart Fliege, *Pepperdine University*
 Edna Frye, *Governors State University*
 Edward Y. George, *University of Texas at El Paso*
 Stephen Grubaugh, *Bentley College*
 Wendel Hewett, *University of Texas, Tyler*
 Peter Hoefler, *Pace University*
 Geoffrey B. Holmewood, *Hudson Valley Community College*
 J. Marcus Jobe, *Miami University Ohio*
 David D. Krueger, *St. Cloud State University*
 Stan Malik, *Governors State University*
 Clifton Miller, *University of Texas of the Permian Basin*
 George Miller, *North Seattle Community College*
 Kurt Moser, *Pepperdine University*
 Lou Mottola, *University of Bridgeport*
 Sumy Renjin, *Pepperdine University*
 Peter Rob, *Tennessee State University*
 Donald L. Schmidt, *American Graduate School of International Business*
 John C. Shannon, *Suffolk University*
 Susan A. Simmons, *Sam Houston State University*
 Rex Snider, *Troy State University*
 George Vlahos, *University of Dayton*
 Edward J. Willies, *Tidewater Community College*
 Robert S. Wu, *Longwood College*
 Jack Yurkiewicz, *Pace University*

Owen P. Hall, Jr.
 Harvey E. Adelman

Contents in Brief

1	INTRODUCTION	1
2	THE ROLE OF STATISTICS IN MANAGERIAL DECISION MAKING	9
3	DESCRIPTIVE STATISTICS	27
4	PROBABILITY THEORY	87
5	PROBABILITY DISTRIBUTIONS	133
6	SURVEY DESIGN AND DATA BASE MANAGEMENT	191
7	SAMPLING AND ESTIMATION	231
8	HYPOTHESIS TESTING	287
9	SIMPLE LINEAR CORRELATION AND REGRESSION	345
10	MULTIPLE REGRESSION ANALYSIS	399
11	TIME SERIES AND FORECASTING	467
12	CHI-SQUARE ANALYSIS	537
13	ANALYSIS OF VARIANCE	579
14	NONPARAMETRIC STATISTICS	629
15	MANAGERIAL DECISION ANALYSIS	677
	APPENDIX A: STATISTICAL TABLES	733
	APPENDIX B: COMPUTERIZED BUSINESS STATISTICS	757
	APPENDIX C: SOLUTIONS TO SELECTED ODD-NUMBERED PROBLEMS	773
	INDEX	791

Contents

1	INTRODUCTION	1
1.1	What Is Business Statistics?	2
1.2	New Developments in Business Statistics	4
1.3	Trends in Teaching Business Statistics	4
1.4	Organization of the Book	5
1.5	Summary	7
1.6	Teaching Supplements	7
2	THE ROLE OF STATISTICS IN MANAGERIAL DECISION MAKING	9
2.1	Introduction	10
2.2	Example Management Problem: National Cancer Institute	11
2.3	Overview of the Scientific Method	12
2.4	Managerial Decision-Making Process	18
2.5	Total Quality Management	20
2.6	Summary	22
2.7	Glossary	22
2.8	Bibliography	23
2.9	Problems	23
3	DESCRIPTIVE STATISTICS	27
3.1	Introduction	29
3.2	Example Management Problem: Global Precious Metal Exchange	29
3.3	How to Recognize a Descriptive Statistics Problem	30
3.4	Descriptive Analysis	30
3.5	Computer Analysis	56

	3.6	Practical Applications	58
	3.7	Case Study: Goodfaith Emergency Clinic	62
	3.8	Summary	64
	3.9	Glossary	65
	3.10	Bibliography	65
	3.11	Problems	66
	3.12	Cases	83
4		PROBABILITY THEORY	87
	4.1	Introduction	88
	4.2	Example Management Problem: The California Lottery	90
	4.3	Basic Rules of Probability	90
	4.4	Fundamental Concepts	91
	4.5	Computer Analysis	110
	4.6	Practical Applications	111
	4.7	Case Study: Automobile Fuel Economy Standards	114
	4.8	Summary	117
	4.9	Glossary	118
	4.10	Bibliography	118
	4.11	Problems	119
	4.12	Cases	129
5		PROBABILITY DISTRIBUTIONS	133
	5.1	Introduction	134
	5.2	Example Management Problem: Seven-Day Tire Company	136
	5.3	Characteristics of a Probability Distribution	137
	5.4	Probability Distributions	137
	5.5	Computer Analysis	169
	5.6	Practical Applications	173
	5.7	Case Study: Drack Industries	176
	5.8	Summary	178
	5.9	Glossary	178
	5.10	Bibliography	179
	5.11	Problems	179
	5.12	Cases	187

6	SURVEY DESIGN AND DATA BASE MANAGEMENT	191
6.1	Introduction	192
6.2	Example Management Problem: Nautilus Health Spa, Inc.	196
6.3	Questionnaire Design	197
6.4	Computer Data Base Management Systems	211
6.5	Practical Applications	214
6.6	Case Study: Transpacific Airlines	218
6.7	Summary	223
6.8	Glossary	224
6.9	Bibliography	225
6.10	Problems	225
6.11	Cases	227
7	SAMPLING AND ESTIMATION	231
7.1	Introduction	232
7.2	Example Management Problem: Wilcox Accounting Services	233
7.3	Basic Characteristics of Sampling and Estimation	235
7.4	Sampling and Estimation	235
7.5	Computer Analysis	264
7.6	Practical Applications	268
7.7	Case Study: Bozart Investments Corporation	270
7.8	Summary	271
7.9	Glossary	272
7.10	Bibliography	273
7.11	Problems	273
7.12	Cases	283
8	HYPOTHESIS TESTING	287
8.1	Introduction	288
8.2	Example Management Problem: Iowa Department of Motor Vehicles	289
8.3	How to Recognize a Hypothesis Testing Problem	290
8.4	Statistical Hypothesis Testing	290
8.5	Computer Analysis	314
8.6	Practical Applications	319
8.7	Case Study: Heartwell Music Experiment	321
8.8	Summary	323

	8.9	Glossary	325
	8.10	Bibliography	326
	8.11	Problems	326
	8.12	Cases	342
9		SIMPLE LINEAR CORRELATION AND REGRESSION	345
	9.1	Introduction	346
	9.2	Example Management Problem: Pacific Construction Company	347
	9.3	How to Recognize a Simple Correlation and Regression Problem	347
	9.4	Model Formulation	349
	9.5	Computer Analysis	366
	9.6	Practical Applications	371
	9.7	Case Study: Pritikin Diet	374
	9.8	Summary	376
	9.9	Glossary	376
	9.10	Bibliography	377
	9.11	Problems	377
	9.12	Cases	395
10		MULTIPLE REGRESSION ANALYSIS	399
	10.1	Introduction	400
	10.2	Example Management Problem: Far Filtration Company	401
	10.3	How to Recognize a Multiple Regression Analysis Problem	402
	10.4	Model Formulation	402
	10.5	Computer Analysis	416
	10.6	Practical Applications	422
	10.7	Case Study: National Baseball League	430
	10.8	Summary	431
	10.9	Glossary	432
	10.10	Bibliography	433
	10.11	Problems	433
	10.12	Cases	462
11		TIME SERIES AND FORECASTING	467
	11.1	Introduction	468
	11.2	Example Management Problem: Dialnet Telephone Exchange	469

11.3	How to Recognize a Time Series Problem	471
11.4	Classical Decomposition Model	471
11.5	Forecasting Models	476
11.6	Forecast Validation	494
11.7	Computer Analysis	496
11.8	Practical Applications	497
11.9	Case Study: Thermhouse Insulation Corporation	502
11.10	Summary	510
11.11	Glossary	511
11.12	Bibliography	512
11.13	Problems	512
11.14	Cases	533
12	CHI-SQUARE ANALYSIS	537
12.1	Introduction	538
12.2	Example Management Problem: Kwan Bottling Co.	539
12.3	How to Recognize a Chi-Square Problem	540
12.4	Model Formulation	540
12.5	Computer Analysis	551
12.6	Practical Applications	553
12.7	Case Study: Leaky Pen Company	559
12.8	Summary	561
12.9	Glossary	562
12.10	Bibliography	562
12.11	Problems	562
12.12	Cases	576
13	ANALYSIS OF VARIANCE	579
13.1	Introduction	580
13.2	Example Management Problem: Mitterand Cable Company	581
13.3	How to Recognize an Analysis of a Variance Problem	582
13.4	Model Formulation	583
13.5	Computer Analysis	593
13.6	Practical Applications	598
13.7	Case Study: Microchip Electronics, Inc.	600
13.8	Summary	603
13.9	Glossary	603

	13.10	Bibliography	604
	13.11	Problems	604
	13.12	Cases	626
14		NONPARAMETRIC STATISTICS	629
	14.1	<i>Introduction</i>	630
	14.2	Example Management Problem: Perpetual Savings	631
	14.3	How to Recognize a Nonparametric Problem	632
	14.4	Basic Nonparametric Models	633
	14.5	Computer Analysis	644
	14.6	Practical Applications	647
	14.7	Case Study: Fujti Motors	651
	14.8	Summary	653
	14.9	Glossary	654
	14.10	Bibliography	655
	14.11	Problems	655
	14.12	Cases	674
15		MANAGERIAL DECISION ANALYSIS	677
	15.1	Introduction	678
	15.2	Example Management Problem: Perpetual Investments Corporation	680
	15.3	How to Recognize a Decision Analysis Problem	682
	15.4	Formulating Decision Analysis Models	682
	15.5	Computer Analysis	703
	15.6	Practical Applications	705
	15.7	Case Study: Cleanall Corporation	709
	15.8	Summary	712
	15.9	Glossary	712
	15.10	Bibliography	713
	15.11	Problems	714
	15.12	Cases	729
		APPENDIX A: Statistical Tables	733
	A.1	Areas under the Normal Curve	734
	A.2	Student <i>t</i> Distribution	735
	A.3	Critical Values of Chi-Squared	736
	A.4	Critical Values of the <i>F</i> Distribution	737
	A.5	Binomial Probability Distribution	740

A.6	Poisson Distribution: Probability of Exactly x Occurrences	748
A.7	Critical Values of the Durbin-Watson Test Statistic	750
A.8	Critical Values of the Studentized Range Distribution (Tukey Test)	752
A.9	Cumulative Distribution Function (Runs Test)	754
APPENDIX B: Computerized Business Statistics		757
APPENDIX C: Solutions to Selected Odd-Numbered Problems		773
INDEX		791

Chapter 1

Introduction

Statistical thinking will one day be as necessary for efficient citizenship as the ability to read and write.

H. G. Wells

CHAPTER OUTLINE

- 1.1 What Is Business Statistics?**
- 1.2 New Developments in Business Statistics**
- 1.3 Trends in Teaching Business Statistics**
- 1.4 Organization of the Book**
- 1.5 Summary**
- 1.6 Teaching Supplements**

“A formal planning system is the key to effective business management.” This refrain is heard with increasing regularity throughout corporate America. An effective planning system incorporates both an internal and an external context, and the status of each context requires continuous updating. Here, statistical analysis plays an important role. Computer-based systems provide the firm with a steady stream of processed data (i.e., information) that can be used for improving corporate decision making.

A recent study investigated some potential ramifications of the use of computer-based planning systems.* This study clearly showed that companies that updated their planning system on a continual basis outperformed (as measured by differences in earnings and absenteeism) those firms that did not use systematic planning. Thus, these types of planning systems offer considerable promise in helping to improve the management decision-making process.

* B. S. Chakravarty, “Tailoring a Strategic Planning System to Its Context,” *Strategic Management Journal* 8, no. 6, pp. 517–31.



1.1 WHAT IS BUSINESS STATISTICS?

To most managers, *statistics* means “numerical descriptions” of specific business or technical data. For example:

- May Company announced that third-quarter net income rose 21% over the past year, to \$104 million.
- The Bureau of Labor Statistics reported that the unemployment rate for March fell below 6%.
- GTE Corporation plans to eliminate 14,000 positions over the next five years.
- The Los Angeles Lakers basketball team had a winning percentage of nearly 65% for the 1987 season.

The primary objective of **business statistics** is to provide quantitative information for decision making. Statistics in general, and business statistics in particular, are often divided into two major categories: descriptive statistics and inferential statistics.

Descriptive statistics includes data collection, data classification, data display (i.e., graphics) and data processing (i.e., computations) such as:

- Product failure rates.
- Customer preference for a new fast-food product.
- Market share data.
- Average wage rates between industry groups.

Inferential statistics represents an important analytical tool for business decision making. The basic premise behind statistical inference is quite simple. Namely, descriptive statistics from a small sample are used to describe a larger, unseen group (i.e., a population). Statistical inference is a necessity in most business situations because data on a **population** of interest are unavailable or unattainable. Consequently, a **sample** is selected to represent the population. In this way the decision maker can infer population characteristics from what is usually a very small sample drawn from the population, as in:

- Identifying the winner of the presidential race after conducting an exit poll of 1% of the voters.
- Determining whether a batch of computer chips can be shipped or must be reprocessed based on a sample inspection of 2% of the lot size.
- Estimating the demand for a new detergent based on testing the product in 500 households.
- Forecasting revenues for next year based on sales data over the last three years.

One of the key business uses of statistical inference is in forecasting. The forecasting process has as its primary objective the prediction or estimation of future events. More specifically, forecasting is the attempt to estimate future changes based on a set of assumptions. There are a wide variety of forecasting methodologies, ranging from subjective approaches to very complex computer-based models. Forecasting can range from an exact science to a naive art. As such, the quality of the forecast depends heavily on the quality of the data and the accuracy of the facilitating assumptions.

HISTORICAL NOTE

The recording of data can be traced back to early man. The book of Numbers in the Bible contains several accounts of early census taking. One of the earliest applications of statistics to business was by the Englishman Thomas Watt (1705–1769) during the early part of the 18th century. Watt established a school with a particular emphasis on mathematics and mensuration. The interest in measurement was short-lived, however, and did not surface again for nearly two centuries.