Bowerman O'Connell Orris



Essentials of

# Essentials of Business Business Statistics

www.mhhe.com/bowermaness1e



Bruce L. Bowerman

Miami University

Richard T. O'Connell

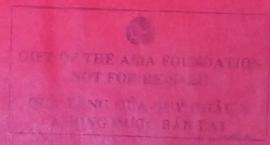
Miami University

J. B. Orris

**Butler University** 

**Essentials of Business Statistics** 







Boston Burr Ridge, IL Dubuque, IA Madison, WI New York San Francisco St. Louis Bangkok Bogotá Caracas Kuala Lumpur Lisbon London Madrid Mexico City Milan Montreal New Delhi Santiago Seoul Singapore Sydney Taipei Toronto



#### ESSENTIALS OF BUSINESS STATISTICS

Published by McGraw-Hill/Irwin, a business unit of The McGraw-Hill Companies, Inc., 1221 Avenue of the Americas, New York, NY, 10020. Copyright © 2004 by The McGraw-Hill Companies, Inc. All rights reserved. No part of this publication may be reproduced or distributed in any form or by any means, or stored reserved. No part of this publication may be reproduced or distributed in any form or by any means, or stored reserved. No part of this publication may be reproduced or distributed in any form or by any means, or stored reserved. No part of this publication may be reproduced or distributed in any form or by any means, or stored reserved. No part of this publication may be reproduced or distributed in any form or by any means, or stored reserved. No part of this publication may be reproduced or distributed in any form or by any means, or stored reserved. No part of this publication may be reproduced or distributed in any form or by any means, or stored reserved. No part of this publication may be reproduced or distributed in any form or by any means, or stored reserved. No part of this publication may be reproduced or distributed in any form or by any means, or stored reserved. No part of this publication may be reproduced or distributed in any form or by any means, or stored reserved. No part of this publication may be reproduced or distributed in any form or by any means, or stored reserved.

This book is printed on acid-free paper.

domestic 1234567890VNH/VNH09876543 international 1234567890VNH/VNH09876543

ISBN 0-07-282782-3

Editorial director: Brent Gordon
Executive editor: Scott Isenberg
Senior developmental editor: Wanda J. Zeman
Senior marketing manager: Douglas Reiner
Producer, Media technology: Anthony Sherman
Project manager: Laura Griffin
Production supervisor: Debra R. Sylvester
Lead designer: Pam Verros
Photo research coordinator: Jeremy Cheshareck
Photo researcher: Billie Porter
Lead supplement producer: Cathy L. Tepper
Senior digital content specialist: Brian Nacik
Cover/interior design: Jennifer McQueen

Compositor: Interactive Composition Corporation

Printer: Von Hoffmann Corporation

Typeface: 10/12 Times Roman

#### Library of Congress Cataloging-in-Publication Data

Bowerman, Bruce L.

Essentials of business statistics / Bruce L. Bowerman, Richard T. O'Connell, J.B. Orris. – 1st ed.

p. cm. – (The McGraw-Hill/Irwin series Operations and decision sciences) neludes index.

ISBN 0-07-282782-3 (alk. paper) – ISBN 0-07-121440-2 (international : alk. paper)
1. Commercial statistics. I. O'Connell, Richard T. II. Orris, J. B. III. Title. IV. Series.
HF1017.B6554 2004
519.5–dc21
2003051019

#### INTERNATIONAL EDITION ISBN 0-07-121440-2

Copyright © 2004. Exclusive rights by The McGraw-Hill Companies, Inc. for manufacture and export. This book cannot be re-exported from the country to which it is sold by McGraw-Hill. The International Edition is not available in North America.

# **Brief Table of Contents**

Chapter 1 An Introduction to Business Statistics	2	Chapter 10 Comparing Proportions and Chi-Square Tests	394
Chapter 2 Descriptive Statistics	38	Chapter 11 Simple Linear Regression Analysis	432
Chapter 3 Probability	120	Chapter 12 Multiple Regression and Model Building	508
Chapter 4 Discrete Random Variables	156	Appendix A Statistical Tables	572
Chapter 5 Continuous Random Variables	192	Appendix B Counting Rules	596
Chapter 6 Sampling Distributions	234	Appendix C The Hypergeometric Distribution	598
Chapter 7 Confidence Intervals	258	Answers to Most Odd-Numbered Exercises	599
Chapter 8 Hypothesis Testing	298	References	609
Chapter 9	346	Photo Credits	611
Comparing Population Means		Index	613

# **Table of Contents**

# Chapter 1

	An	Introdu	ction to	Business	Statistics
--	----	---------	----------	----------	------------

- 1.1 Populations and Samples
- 1.2 Sampling a Population of Existing Units 4
- 1.3 Sampling a Process 12
- \*1.4 Ratio, Interval, Ordinal, and Nominative Scales of Measurement 20
- App 1.1 Getting Started with MINITAB 24
- App 1.2 Getting Started with Excel 29
- App 1.3 Getting Started with MegaStat 32
- App 1.4 Introduction to Internet Exercises 36

# Chapter 2

#### Descriptive Statistics

- 2.1 Describing the Shape of a Distribution 39
- 2.2 Describing Central Tendency 55
- 2.3 Measures of Variation 64
- 2.4 Percentiles, Quartiles, and Box-and-Whiskers Displays 75
- 2.5 Describing Qualitative Data 84
- \*2.6 Using Scatter Plots to Study Relationships between Variables 91
- \*2.7 Misleading Graphs and Charts 93
- \*2.8 Weighted Means and Grouped Data 97
- \*2.9 The Geometric Mean 101
- App 2.1 Descriptive Statistics Using MINITAB 111
- App 2.2 Descriptive Statistics Using Excel 114
- App 2.3 Descriptive Statistics Using MegaStat 117

# Chapter 3

#### Probability

- 3.1 The Concept of Probability 121
- 3.2 Sample Spaces and Events 123
- 3.3 Some Elementary Probability Rules 130
- 3.4 Conditional Probability and Independence 137
- \*3.5 Bayes' Theorem 148

# **Chapter 4**

#### Discrete Random Variables

- 4.1 Two Types of Random Variables 157
- 4.2 Discrete Probability Distributions 158

4.3 The Binomial Distribution 169  *4.4 The Poisson Distribution 180  App 4.1 Binomial and Poisson Probabilities Using MINITAB 188  App 4.2 Binomial and Poisson Probabilities Using Excel 188  App 4.3 Binomial and Poisson Probabilities Using MegaStat 190
Chapter 5 Continuous Random Variables 5.1  Continuous Probability Distributions 193 5.2 The Uniform Distribution 195 5.3 The Normal Probability Distribution 198 *5.4 Approximating the Binomial Distribution by Using the Normal Distribution 216 *5.5 The Exponential Distribution 220 *5.6 The Cumulative Normal Table 222 App 5.1 Normal Distribution Using MINITAB 230 App 5.2 Normal Distribution Using Excel 231 App 5.3 Normal Distribution Using MegaStat 233
Chapter 6 Sampling Distributions 6.1 The Sampling Distribution of the Sample Mean 235 6.2 The Sampling Distribution of the Sample Proportion 248 App 6.1 Simulating Sampling Distributions Using MINITAB 256
Chapter 7 Confidence Intervals 7.1 Large Sample Confidence Intervals for a Population Mean 259 7.2 Small Sample Confidence Intervals for a Population Mean 268 7.3 Sample Size Determination 276 7.4 Confidence Intervals for a Population Proportion 280 *7.5 A Comparison of Confidence Intervals and Tolerance Intervals 287 App 7.1 Confidence Intervals Using MINITAB 293 App 7.2 Confidence Intervals Using Excel 294 App 7.3 Confidence Intervals Using MegaStat 295
Chapter 8  Hypothesis Testing  8.1 The Null and Alternative Hypotheses and Errors in Hypothesis Testing  8.2 Large Sample Tests about a Population Mean: One-Sided Alternatives  8.3 Large Sample Tests about a Population Mean: Two-Sided Alternatives  8.4 Small Sample Tests about a Population Mean 321  8.5 Tests about a Population Proportion 326  *8.6 Type II Error Probabilities and Sample Size Determination 331  App 8.1 One-Sample Hypothesis Testing Using MINITAB 343  App 8.2 One-Sample Hypothesis Testing Using Excel 344

App 8.3 One-Sample Hypothesis Testing Using MegaStat 345

Table of Contents

# **Chapter 9**

Com	paring	Populatio	on Means
COLLE	PLUI 1112	1 (2) 2) 11 121 11	JII IVICALIS

- 9.1 Comparing Two Population Means by Using Large, Independent Samples 347
- 9.2 Comparing Two Population Means by Using Small, Independent Samples 354
- 9.3 Paired Difference Experiments 361
- 9.4 Basic Concepts of Experimental Design 369
- 9.5 One-Way Analysis of Variance 372
- App 9.1 Two-Sample t Tests and One-Way ANOVA Using MINITAB 388
- App 9.2 Two-Sample t Tests and One-Way ANOVA Using Excel 390
- App 9.3 Two-Sample t Tests and One-Way ANOVA Using MegaStat 391

# Chapter 10

#### Comparing Proportions and Chi-Square Tests

- 10.1 Comparing Two Population Proportions by Using Large, Independent Samples 395
- 10.2 The Chi-Square Distribution 401
- 10.3 Chi-Square Goodness of Fit Tests 402
- 10.4 A Chi-Square Test for Independence 411
- App 10.1 Comparing Proportions and Chi-Square Tests Using MINITAB 424
- App 10.2 Chi-Square Tests Using Excel 426
- App 10.3 Comparing Proportions and Chi-Square Tests Using MegaStat 428

# Chapter 11

#### Simple Linear Regression Analysis

- 11.1 The Simple Linear Regression Model 433
- 11.2 The Least Squares Estimates, and Point Estimation and Prediction 444
- 11.3 Model Assumptions and the Standard Error 453
- 11.4 Testing the Significance of the Slope and y Intercept 456
- 11.5 Confidence and Prediction Intervals 465
- 11.6 Simple Coefficients of Determination and Correlation 473
- 11.7 An F Test for the Model 479
- \*11.8 Residual Analysis 481
- \*11.9 Some Shortcut Formulas 494
- App 11.1 Simple Linear Regression Analysis Using MINITAB 503
- App 11.2 Simple Linear Regression Analysis Using Excel 504
- App 11.3 Simple Linear Regression Analysis Using MegaStat 506

# Chapter 12

#### Multiple Regression and Model Building

- 12.1 The Linear Regression Model 509
- 12.2 The Least Squares Estimates, and Point Estimation and Prediction 517
- 12.3 The Mean Square Error and the Standard Error 524
- 12.4 Model Utility:  $R^2$ , Adjusted  $R^2$ , and the Overall F Test 525
- 12.5 Testing the Significance of an Independent Variable 528
- 12.6 Confidence and Prediction Intervals 532
- 12.7 Dummy Variables, and an Introduction to Interaction 535
- 12.8 Model Building, and the Effects of Multicollinearity 546

12.9 Residual Analysis in Multiple Regression 554

App 12.1 Multiple Linear Regression Analysis Using MINITAB 565

App 12.2 Multiple Linear Regression Analysis Using Excel 567

App 12.3 Multiple Linear Regression Analysis Using MegaStat 569

# Appendix A

Statistical Tables 572

# Appendix B

Counting Rules 596

# Appendix C

The Hypergeometric Distribution 598

Answers to Most Odd-Numbered Exercises 599

References 609

Photo Credits 611

Index 613