

FOURTH EDITION


# BUSINESS INTELLIGENCE, ANALYTICS, AND DATA SCIENCE:

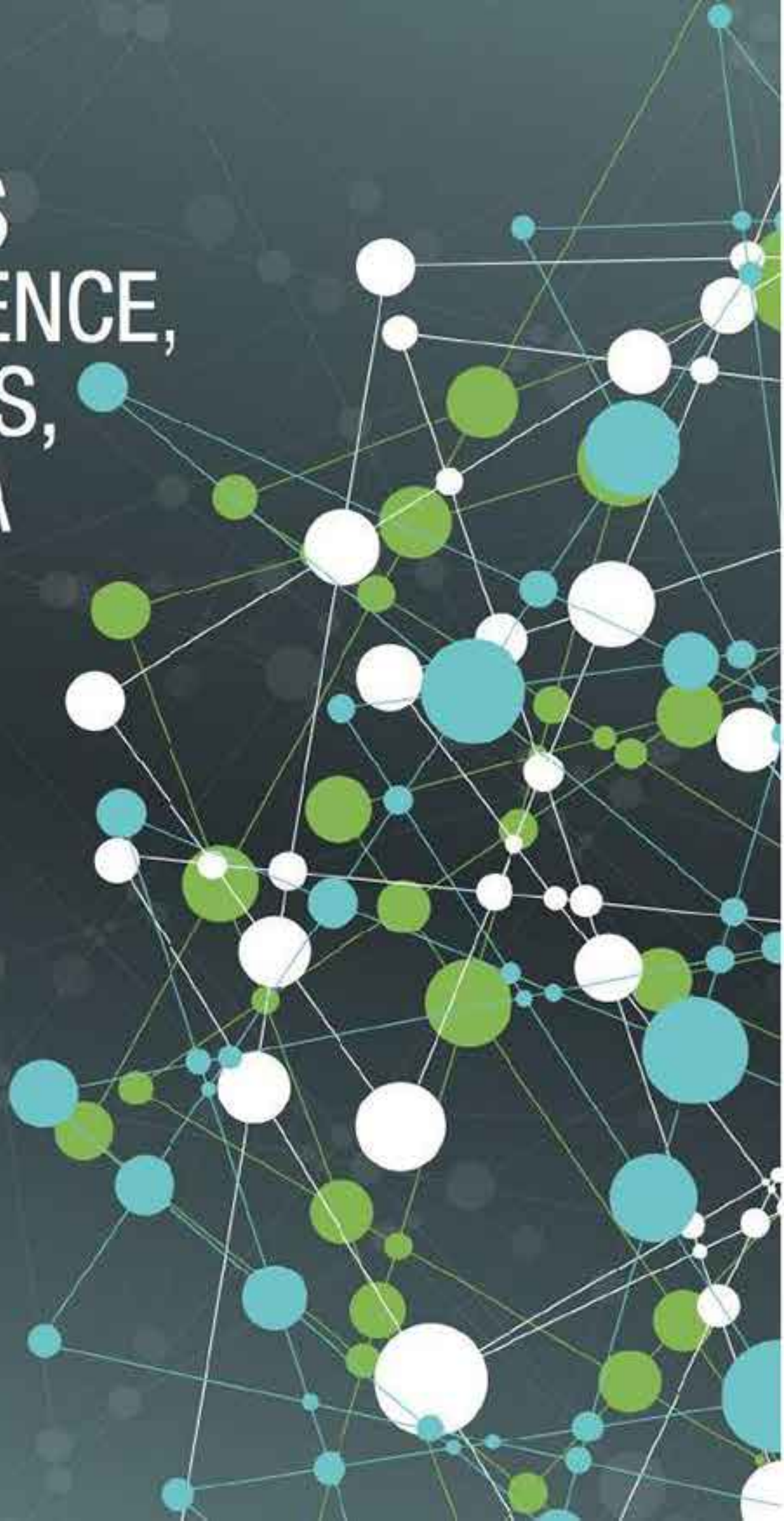
*A Managerial  
Perspective*

Ramesh Sharda

Dursun Delen

Efraim Turban

 Pearson



## OTHER MIS TITLES OF INTEREST

### Introductory MIS

**Experiencing MIS, 7/e**

Kroenke & Boyle ©2017

**Using MIS, 10/e**

Kroenke & Boyle ©2018

**Management Information Systems, 15/e**

Laudon & Laudon ©2018

**Essentials of MIS, 12/e**

Laudon & Laudon ©2017

**IT Strategy, 3/e**

McKeen & Smith ©2015

**Processes, Systems, and Information: An Introduction to MIS, 2/e**

McKinney & Kroenke ©2015

**Information Systems Today, 8/e**

Valacich & Schneider ©2018

**Introduction to Information Systems, 3/e**

Wallace ©2018

### Database

**Hands-on Database, 2/e**

Conger ©2014

**Modern Database Management, 12/e**

Hoffer, Ramesh & Topi ©2016

**Database Concepts, 8/e**

Kroenke, Auer, Vandenburg, Yoder ©2018

**Database Processing, 14/e**

Kroenke & Auer ©2016

### Systems Analysis and Design

**Modern Systems Analysis and Design, 8/e**

Hoffer, George & Valacich ©2017

**Systems Analysis and Design, 9/e**

Kendall & Kendall ©2014

**Essentials of Systems Analysis and Design, 6/e**

Valacich, George & Hoffer ©2015

### Decision Support Systems

**Business Intelligence, Analytics, and Data Science, 4/e**

Sharda, Delen & Turban ©2018

**Business Intelligence and Analytics: Systems for Decision Support, 10/e**

Sharda, Delen & Turban ©2014

### Data Communications & Networking

**Applied Networking Labs, 2/e**

Boyle ©2014

**Digital Business Networks**

Dooley ©2014

**Business Data Networks and Security, 10/e**

Panko & Panko ©2015

### Electronic Commerce

**E-Commerce: Business, Technology, Society, 13/e**

Laudon & Traver ©2018

### Enterprise Resource Planning

**Enterprise Systems for Management, 2/e**

Motiwalla & Thompson ©2012

### Project Management

**Project Management: Process, Technology and Practice**

Vaidyanathan ©2013

FOURTH EDITION

# BUSINESS INTELLIGENCE, ANALYTICS, AND DATA SCIENCE:

## A Managerial Perspective

**Ramesh Sharda**

*Oklahoma State University*

**Dursun Delen**

*Oklahoma State University*

**Efraim Turban**

*University of Hawaii*

*With contributions to previous editions by*

**J. E. Aronson**

*The University of Georgia*

**Ting-Peng Liang**

*National Sun Yat-sen University*

**David King**

*JDA Software Group, Inc.*



330 Hudson Street, NY NY 10013

**VP Editorial Director:** Andrew Gilfillan  
**Senior Portfolio Manager:** Samantha Lewis  
**Content Development Team Lead:** Laura Burgess  
**Content Developer:** Stephany Harrington  
**Program Monitor:** Ann Pulido/SPi Global  
**Editorial Assistant:** Madeline Houpt  
**Product Marketing Manager:** Kaylee Carlson  
**Project Manager:** Revathi Viswanathan/Cenveo  
Publisher Services  
**Text Designer:** Cenveo Publisher Services

**Cover Designer:** Brian Malloy/Cenveo Publisher  
Services  
**Cover Art:** Olga Morkotun/Shutterstock  
**Full-Service Project Management:** Cenveo  
Publisher Services  
**Composition:** Cenveo Publisher Services  
**Printer/Binder:** RR Donnelley/Willard  
**Cover Printer:** Phoenix  
**Text Font:** 10/12 Times LT Pro

Credits and acknowledgments borrowed from other sources and reproduced, with permission, in this textbook appear on the appropriate page within text.

Microsoft and/or its respective suppliers make no representations about the suitability of the information contained in the documents and related graphics published as part of the services for any purpose. All such documents and related graphics are provided as is without warranty of any kind. Microsoft and/or its respective suppliers hereby disclaim all warranties and conditions with regard to this information, including all warranties and conditions of merchantability, whether express, implied or statutory, fitness for a particular purpose, title and non-infringement.

In no event shall Microsoft and/or its respective suppliers be liable for any special, indirect or consequential damages or any damages whatsoever resulting from loss of use, data or profits, whether in an action of contract, negligence or other tortious action, arising out of or in connection with the use or performance of information available from the services. The documents and related graphics contained herein could include technical inaccuracies or typographical errors. Changes are periodically added to the information herein. Microsoft and/or its respective suppliers may make improvements and/or changes in the product(s) and/or the program(s) described herein at any time. Partial screen shots may be viewed in full within the software version specified.

Microsoft® Windows®, and Microsoft Office® are registered trademarks of the Microsoft Corporation in the U.S.A. and other countries. This book is not sponsored or endorsed by or affiliated with the Microsoft Corporation.

---

**Copyright © 2018, 2014, 2011, 2008 by Pearson Education, Inc., or its affiliates.** All rights reserved.

Manufactured in the United States of America. This publication is protected by Copyright, and permission should be obtained from the publisher prior to any prohibited reproduction, storage in a retrieval system, or transmission in any form or by any means, electronic, mechanical, photocopying, recording, or likewise.

To obtain permission(s) to use material from this work, please submit a written request to Pearson Education, Inc., Permissions Department, One Lake Street, Upper Saddle River, New Jersey 07458, or you may fax your request to 201-236-3290.

Many of the designations by manufacturers and sellers to distinguish their products are claimed as trademarks.

Where those designations appear in this book, and the publisher was aware of a trademark claim, the designations have been printed in initial caps or all caps.

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

Names: Sharda, Ramesh, author. | Delen, Dursun, author. | Turban, Efraim, author.

Title: Business intelligence, analytics, and data science : a managerial perspective / Ramesh Sharda, Oklahoma State University, Dursun Delen, Oklahoma State University, Efraim Turban, University of Hawaii ; with contributions by J. E. Aronson, The University of Georgia, Ting-Peng Liang, National Sun Yat-sen University, David King, JDA Software Group, Inc.

Other titles: Business intelligence

Description: Fourth edition. | Boston : Pearson, [2016] | Earlier edition published as: Business intelligence : a managerial perspective on analytics. | Includes index.

Identifiers: LCCN 2016031095 | ISBN 9780134633282 | ISBN 0134633288

Subjects: LCSH: Business intelligence. | Industrial management.

Classification: LCC HD38.7 .B8714 2016 | DDC 658.4/72-dc23 LC record available at <https://lcn.loc.gov/2016031095>



# Brief Contents

---

Preface xix

About the Authors xxv

- Chapter 1** An Overview of Business Intelligence, Analytics, and Data Science 3
- Chapter 2** Descriptive Analytics I: Nature of Data, Statistical Modeling, and Visualization 53
- Chapter 3** Descriptive Analytics II: Business Intelligence and Data Warehousing 127
- Chapter 4** Predictive Analytics I: Data Mining Process, Methods, and Algorithms 189
- Chapter 5** Predictive Analytics II: Text, Web, and Social Media Analytics 247
- Chapter 6** Prescriptive Analytics: Optimization and Simulation 319
- Chapter 7** Big Data Concepts and Tools 369
- Chapter 8** Future Trends, Privacy and Managerial Considerations in Analytics 417

Glossary 467

Index 475

This page intentionally left blank

# Contents

Preface xix

About the Authors xxv

## Chapter 1 An Overview of Business Intelligence, Analytics, and Data Science 3

- 1.1 OPENING VIGNETTE: Sports Analytics—An Exciting Frontier for Learning and Understanding Applications of Analytics 4
- 1.2 Changing Business Environments and Evolving Needs for Decision Support and Analytics 11
- 1.3 Evolution of Computerized Decision Support to Analytics/Data Science 13
- 1.4 A Framework for Business Intelligence 15
  - Definitions of BI 16
  - A Brief History of BI 16
  - The Architecture of BI 16
  - The Origins and Drivers of BI 16
    - ▶ **APPLICATION CASE 1.1 Sabre Helps Its Clients through Dashboards and Analytics** 18
  - A Multimedia Exercise in Business Intelligence 19
  - Transaction Processing versus Analytic Processing 19
  - Appropriate Planning and Alignment with the Business Strategy 20
  - Real-Time, On-Demand BI Is Attainable 21
  - Developing or Acquiring BI Systems 21
  - Justification and Cost–Benefit Analysis 22
  - Security and Protection of Privacy 22
  - Integration of Systems and Applications 22
- 1.5 Analytics Overview 22
  - Descriptive Analytics 24
    - ▶ **APPLICATION CASE 1.2 Silvaris Increases Business with Visual Analysis and Real-Time Reporting Capabilities** 24
    - ▶ **APPLICATION CASE 1.3 Siemens Reduces Cost with the Use of Data Visualization** 25
  - Predictive Analytics 25
    - ▶ **APPLICATION CASE 1.4 Analyzing Athletic Injuries** 26
  - Prescriptive Analytics 26
  - Analytics Applied to Different Domains 27
    - ▶ **APPLICATION CASE 1.5 A Specialty Steel Bar Company Uses Analytics to Determine Available-to-Promise Dates** 27
  - Analytics or Data Science? 28

1.6 Analytics Examples in Selected Domains	29
Analytics Applications in Healthcare—Humana Examples	29
Analytics in the Retail Value Chain	33
1.7 A Brief Introduction to Big Data Analytics	35
What Is Big Data?	35
▶ <b>APPLICATION CASE 1.6 CenterPoint Energy Uses Real-Time Big Data Analytics to Improve Customer Service</b>	37
1.8 An Overview of the Analytics Ecosystem	37
Data Generation Infrastructure Providers	39
Data Management Infrastructure Providers	39
Data Warehouse Providers	40
Middleware Providers	40
Data Service Providers	40
Analytics-Focused Software Developers	41
Application Developers: Industry Specific or General	42
Analytics Industry Analysts and Influencers	43
Academic Institutions and Certification Agencies	44
Regulators and Policy Makers	45
Analytics User Organizations	45
1.9 Plan of the Book	46
1.10 Resources, Links, and the Teradata University Network Connection	47
Resources and Links	47
Vendors, Products, and Demos	48
Periodicals	48
The Teradata University Network Connection	48
The Book's Web Site	48
<i>Chapter Highlights</i>	49
<i>Key Terms</i>	49
<i>Questions for Discussion</i>	49
<i>Exercises</i>	50
<i>References</i>	51

---

## **Chapter 2** Descriptive Analytics I: Nature of Data, Statistical Modeling, and Visualization 53

2.1 OPENING VIGNETTE: SiriusXM Attracts and Engages a New Generation of Radio Consumers with Data-Driven Marketing	54
2.2 The Nature of Data	57
2.3 A Simple Taxonomy of Data	61
▶ <b>APPLICATION CASE 2.1 Medical Device Company Ensures Product Quality While Saving Money</b>	63



- 2.4 The Art and Science of Data Preprocessing 65
  - ▶ **APPLICATION CASE 2.2 Improving Student Retention with Data-Driven Analytics** 68
- 2.5 Statistical Modeling for Business Analytics 74
  - Descriptive Statistics for Descriptive Analytics 75
  - Measures of Centrality Tendency (May Also Be Called Measures of Location or Centrality) 76
  - Arithmetic Mean 76
  - Median 77
  - Mode 77
  - Measures of Dispersion (May Also Be Called Measures of Spread or Decentrality) 77
  - Range 78
  - Variance 78
  - Standard Deviation 78
  - Mean Absolute Deviation 78
  - Quartiles and Interquartile Range 78
  - Box-and-Whiskers Plot 79
  - The Shape of a Distribution 80
    - ▶ **APPLICATION CASE 2.3 Town of Cary Uses Analytics to Analyze Data from Sensors, Assess Demand, and Detect Problems** 84
- 2.6 Regression Modeling for Inferential Statistics 86
  - How Do We Develop the Linear Regression Model? 87
  - How Do We Know If the Model Is Good Enough? 88
  - What Are the Most Important Assumptions in Linear Regression? 89
  - Logistic Regression 90
    - ▶ **APPLICATION CASE 2.4 Predicting NCAA Bowl Game Outcomes** 91
  - Time Series Forecasting 96
- 2.7 Business Reporting 98
  - ▶ **APPLICATION CASE 2.5 Flood of Paper Ends at FEMA** 100
- 2.8 Data Visualization 101
  - A Brief History of Data Visualization 101
    - ▶ **APPLICATION CASE 2.6 Macfarlan Smith Improves Operational Performance Insight with Tableau Online** 103
- 2.9 Different Types of Charts and Graphs 106
  - Basic Charts and Graphs 106
  - Specialized Charts and Graphs 107
  - Which Chart or Graph Should You Use? 108
- 2.10 The Emergence of Visual Analytics 110
  - Visual Analytics 112
  - High-Powered Visual Analytics Environments 112

2.11 Information Dashboards	117
▶ <b>APPLICATION CASE 2.7 Dallas Cowboys Score Big with Tableau and Teknion</b>	118
Dashboard Design	119
▶ <b>APPLICATION CASE 2.8 Visual Analytics Helps Energy Supplier Make Better Connections</b>	119
What to Look for in a Dashboard	121
Best Practices in Dashboard Design	121
Benchmark Key Performance Indicators with Industry Standards	121
Wrap the Dashboard Metrics with Contextual Metadata	121
Validate the Dashboard Design by a Usability Specialist	122
Prioritize and Rank Alerts/Exceptions Streamed to the Dashboard	122
Enrich Dashboard with Business-User Comments	122
Present Information in Three Different Levels	122
Pick the Right Visual Construct Using Dashboard Design Principles	122
Provide for Guided Analytics	122
<i>Chapter Highlights</i>	123
<i>Key Terms</i>	123
<i>Questions for Discussion</i>	124
<i>Exercises</i>	124
<i>References</i>	126

---

## **Chapter 3** Descriptive Analytics II: Business Intelligence and Data Warehousing 127

3.1 OPENING VIGNETTE: Targeting Tax Fraud with Business Intelligence and Data Warehousing	128
3.2 Business Intelligence and Data Warehousing	130
What Is a Data Warehouse?	131
A Historical Perspective to Data Warehousing	132
Characteristics of Data Warehousing	133
Data Marts	134
Operational Data Stores	135
Enterprise Data Warehouses (EDW)	135
Metadata	135
▶ <b>APPLICATION CASE 3.1 A Better Data Plan: Well-Established TELCOs Leverage Data Warehousing and Analytics to Stay on Top in a Competitive Industry</b>	135
3.3 Data Warehousing Process	137
3.4 Data Warehousing Architectures	139
Alternative Data Warehousing Architectures	142
Which Architecture Is the Best?	144

3.5	Data Integration and the Extraction, Transformation, and Load (ETL) Processes	145
	Data Integration	146
	▶ <b>APPLICATION CASE 3.2 BP Lubricants Achieves BIGS Success</b>	146
	Extraction, Transformation, and Load	148
3.6	Data Warehouse Development	150
	▶ <b>APPLICATION CASE 3.3 Use of Teradata Analytics for SAP Solutions Accelerates Big Data Delivery</b>	151
	Data Warehouse Development Approaches	153
	Additional Data Warehouse Development Considerations	156
	Representation of Data in Data Warehouse	156
	Analysis of Data in Data Warehouse	158
	OLAP versus OLTP	158
	OLAP Operations	159
3.7	Data Warehousing Implementation Issues	160
	Massive Data Warehouses and Scalability	162
	▶ <b>APPLICATION CASE 3.4 EDW Helps Connect State Agencies in Michigan</b>	163
3.8	Data Warehouse Administration, Security Issues, and Future Trends	164
	The Future of Data Warehousing	165
3.9	Business Performance Management	170
	Closed-Loop BPM Cycle	171
	▶ <b>APPLICATION CASE 3.5 AARP Transforms Its BI Infrastructure and Achieves a 347% ROI in Three Years</b>	173
3.10	Performance Measurement	175
	Key Performance Indicator (KPI)	175
	Performance Measurement System	176
3.11	Balanced Scorecards	177
	The Four Perspectives	177
	The Meaning of Balance in BSC	179
3.12	Six Sigma as a Performance Measurement System	179
	The DMAIC Performance Model	180
	Balanced Scorecard versus Six Sigma	180
	Effective Performance Measurement	181
	▶ <b>APPLICATION CASE 3.6 Expedia.com's Customer Satisfaction Scorecard</b>	182
	Chapter Highlights	183
	Key Terms	184
	Questions for Discussion	184
	Exercises	185
	References	187

## Chapter 4 Predictive Analytics I: Data Mining Process, Methods, and Algorithms 189

- 4.1 OPENING VIGNETTE: Miami-Dade Police Department Is Using Predictive Analytics to Foresee and Fight Crime 190
- 4.2 Data Mining Concepts and Applications 193
  - ▶ **APPLICATION CASE 4.1 Visa Is Enhancing the Customer Experience While Reducing Fraud with Predictive Analytics and Data Mining** 194
  - Definitions, Characteristics, and Benefits 196
  - How Data Mining Works 197
    - ▶ **APPLICATION CASE 4.2 Dell Is Staying Agile and Effective with Analytics in the 21st Century** 198
  - Data Mining versus Statistics 203
- 4.3 Data Mining Applications 203
  - ▶ **APPLICATION CASE 4.3 Predictive Analytics and Data Mining Help Stop Terrorist Funding** 205
- 4.4 Data Mining Process 206
  - Step 1: Business Understanding 207
  - Step 2: Data Understanding 208
  - Step 3: Data Preparation 208
  - Step 4: Model Building 209
    - ▶ **APPLICATION CASE 4.4 Data Mining Helps in Cancer Research** 209
  - Step 5: Testing and Evaluation 212
  - Step 6: Deployment 212
  - Other Data Mining Standardized Processes and Methodologies 212
- 4.5 Data Mining Methods 215
  - Classification 215
  - Estimating the True Accuracy of Classification Models 216
    - ▶ **APPLICATION CASE 4.5 Influence Health Uses Advanced Predictive Analytics to Focus on the Factors That Really Influence People's Healthcare Decisions** 223
  - Cluster Analysis for Data Mining 225
  - Association Rule Mining 227
- 4.6 Data Mining Software Tools 231
  - ▶ **APPLICATION CASE 4.6 Data Mining Goes to Hollywood: Predicting Financial Success of Movies** 233
- 4.7 Data Mining Privacy Issues, Myths, and Blunders 237
  - ▶ **APPLICATION CASE 4.7 Predicting Customer Buying Patterns—The Target Story** 238
  - Data Mining Myths and Blunders 238
    - Chapter Highlights 241
    - Key Terms 242
    - Questions for Discussion 242
    - Exercises 243
    - References 245

---

**Chapter 5 Predictive Analytics II: Text, Web, and Social Media Analytics 247**

- 5.1 OPENING VIGNETTE: Machine versus Men on Jeopardy!: The Story of Watson 248
- 5.2 Text Analytics and Text Mining Overview 251
  - ▶ **APPLICATION CASE 5.1 Insurance Group Strengthens Risk Management with Text Mining Solution** 254
- 5.3 Natural Language Processing (NLP) 255
  - ▶ **APPLICATION CASE 5.2 AMC Networks Is Using Analytics to Capture New Viewers, Predict Ratings, and Add Value for Advertisers in a Multichannel World** 257
- 5.4 Text Mining Applications 261
  - Marketing Applications 261
  - Security Applications 261
    - ▶ **APPLICATION CASE 5.3 Mining for Lies** 262
  - Biomedical Applications 264
  - Academic Applications 266
    - ▶ **APPLICATION CASE 5.4 Bringing the Customer into the Quality Equation: Lenovo Uses Analytics to Rethink Its Redesign** 266
- 5.5 Text Mining Process 268
  - Task 1: Establish the Corpus 269
  - Task 2: Create the Term–Document Matrix 269
  - Task 3: Extract the Knowledge 271
    - ▶ **APPLICATION CASE 5.5 Research Literature Survey with Text Mining** 273
- 5.6 Sentiment Analysis 276
  - ▶ **APPLICATION CASE 5.6 Creating a Unique Digital Experience to Capture the Moments That Matter at Wimbledon** 277
  - Sentiment Analysis Applications 280
  - Sentiment Analysis Process 282
  - Methods for Polarity Identification 284
  - Using a Lexicon 284
  - Using a Collection of Training Documents 285
  - Identifying Semantic Orientation of Sentences and Phrases 286
  - Identifying Semantic Orientation of Documents 286
- 5.7 Web Mining Overview 287
  - Web Content and Web Structure Mining 289
- 5.8 Search Engines 291
  - Anatomy of a Search Engine 292
  - I. Development Cycle 292

- 2. Response Cycle 293
- Search Engine Optimization 294
- Methods for Search Engine Optimization 295
  - ▶ **APPLICATION CASE 5.7 Understanding Why Customers Abandon Shopping Carts Results in a \$10 Million Sales Increase** 297
- 5.9 Web Usage Mining (Web Analytics) 298
  - Web Analytics Technologies 299
  - Web Analytics Metrics 300
  - Web Site Usability 300
  - Traffic Sources 301
  - Visitor Profiles 302
  - Conversion Statistics 302
- 5.10 Social Analytics 304
  - Social Network Analysis 304
  - Social Network Analysis Metrics 305
    - ▶ **APPLICATION CASE 5.8 Tito's Vodka Establishes Brand Loyalty with an Authentic Social Strategy** 305
  - Connections 308
  - Distributions 308
  - Segmentation 309
  - Social Media Analytics 309
  - How Do People Use Social Media? 310
  - Measuring the Social Media Impact 311
  - Best Practices in Social Media Analytics 311
    - Chapter Highlights* 313
    - Key Terms* 314
    - Questions for Discussion* 315
    - Exercises* 315
    - References* 316

---

## **Chapter 6 Prescriptive Analytics: Optimization and Simulation 319**

- 6.1 OPENING VIGNETTE: School District of Philadelphia Uses Prescriptive Analytics to Find Optimal Solution for Awarding Bus Route Contracts 320
- 6.2 Model-Based Decision Making 322
  - Prescriptive Analytics Model Examples 322
    - ▶ **APPLICATION CASE 6.1 Optimal Transport for ExxonMobil Downstream through a DSS** 323

Identification of the Problem and Environmental Analysis	324
Model Categories	324
▶ <b>APPLICATION CASE 6.2 Ingram Micro Uses Business Intelligence Applications to Make Pricing Decisions</b>	325
6.3 Structure of Mathematical Models for Decision Support	328
The Components of Decision Support Mathematical Models	328
The Structure of Mathematical Models	329
6.4 Certainty, Uncertainty, and Risk	330
Decision Making under Certainty	330
Decision Making under Uncertainty	331
Decision Making under Risk (Risk Analysis)	331
6.5 Decision Modeling with Spreadsheets	331
▶ <b>APPLICATION CASE 6.3 American Airlines Uses Should-Cost Modeling to Assess the Uncertainty of Bids for Shipment Routes</b>	332
▶ <b>APPLICATION CASE 6.4 Pennsylvania Adoption Exchange Uses Spreadsheet Model to Better Match Children with Families</b>	333
▶ <b>APPLICATION CASE 6.5 Metro Meals on Wheels Treasure Valley Uses Excel to Find Optimal Delivery Routes</b>	334
6.6 Mathematical Programming Optimization	336
▶ <b>APPLICATION CASE 6.6 Mixed-Integer Programming Model Helps the University of Tennessee Medical Center with Scheduling Physicians</b>	337
Linear Programming Model	338
Modeling in LP: An Example	339
Implementation	344
6.7 Multiple Goals, Sensitivity Analysis, What-If Analysis, and Goal Seeking	346
Multiple Goals	346
Sensitivity Analysis	347
What-If Analysis	348
Goal Seeking	348
6.8 Decision Analysis with Decision Tables and Decision Trees	349
Decision Tables	350
Decision Trees	351
6.9 Introduction to Simulation	352
Major Characteristics of Simulation	352
▶ <b>APPLICATION CASE 6.7 Simulating Effects of Hepatitis B Interventions</b>	353
Advantages of Simulation	354
Disadvantages of Simulation	355
The Methodology of Simulation	355

Simulation Types	356
Monte Carlo Simulation	357
Discrete Event Simulation	358
▶ <b>APPLICATION CASE 6.8 Cosan Improves Its Renewable Energy Supply Chain Using Simulation</b>	358
6.10 Visual Interactive Simulation	359
Conventional Simulation Inadequacies	359
Visual Interactive Simulation	359
Visual Interactive Models and DSS	360
Simulation Software	360
▶ <b>APPLICATION CASE 6.9 Improving Job-Shop Scheduling Decisions through RFID: A Simulation-Based Assessment</b>	361
<i>Chapter Highlights</i>	364
<i>Key Terms</i>	364
<i>Questions for Discussion</i>	365
<i>Exercises</i>	365
<i>References</i>	367

---

## Chapter 7 Big Data Concepts and Tools 369

7.1 OPENING VIGNETTE: Analyzing Customer Churn in a Telecom Company Using Big Data Methods	370
7.2 Definition of Big Data	373
The “V”s That Define Big Data	374
▶ <b>APPLICATION CASE 7.1 Alternative Data for Market Analysis or Forecasts</b>	377
7.3 Fundamentals of Big Data Analytics	378
Business Problems Addressed by Big Data Analytics	381
▶ <b>APPLICATION CASE 7.2 Top Five Investment Bank Achieves Single Source of the Truth</b>	382
7.4 Big Data Technologies	383
MapReduce	383
Why Use MapReduce?	385
Hadoop	385
How Does Hadoop Work?	385
Hadoop Technical Components	386
Hadoop: The Pros and Cons	387
NoSQL	389
▶ <b>APPLICATION CASE 7.3 eBay’s Big Data Solution</b>	390
▶ <b>APPLICATION CASE 7.4 Understanding Quality and Reliability of Healthcare Support Information on Twitter</b>	392



- 7.5 Big Data and Data Warehousing 393
  - Use Cases for Hadoop 393
  - Use Cases for Data Warehousing 394
  - The Gray Areas (Any One of the Two Would Do the Job) 395
  - Coexistence of Hadoop and Data Warehouse 396
- 7.6 Big Data Vendors and Platforms 397
  - IBM InfoSphere BigInsights 398
    - ▶ **APPLICATION CASE 7.5 Using Social Media for Nowcasting the Flu Activity** 400
  - Teradata Aster 401
    - ▶ **APPLICATION CASE 7.6 Analyzing Disease Patterns from an Electronic Medical Records Data Warehouse** 402
- 7.7 Big Data and Stream Analytics 406
  - Stream Analytics versus Perpetual Analytics 408
  - Critical Event Processing 408
  - Data Stream Mining 408
- 7.8 Applications of Stream Analytics 409
  - e-Commerce 409
  - Telecommunications 409
    - ▶ **APPLICATION CASE 7.7 Salesforce Is Using Streaming Data to Enhance Customer Value** 410
  - Law Enforcement and Cybersecurity 411
  - Power Industry 411
  - Financial Services 411
  - Health Sciences 411
  - Government 412
    - Chapter Highlights* 412
    - Key Terms* 413
    - Questions for Discussion* 413
    - Exercises* 413
    - References* 414

---

## **Chapter 8** Future Trends, Privacy and Managerial Considerations in Analytics 417

- 8.1 OPENING VIGNETTE: Analysis of Sensor Data Helps Siemens Avoid Train Failures 418
- 8.2 Internet of Things 419
  - ▶ **APPLICATION CASE 8.1 SilverHook Powerboats Uses Real-Time Data Analysis to Inform Racers and Fans** 420
  - ▶ **APPLICATION CASE 8.2 Rockwell Automation Monitors Expensive Oil and Gas Exploration Assets** 421
- IoT Technology Infrastructure 422

RFID Sensors	422
Fog Computing	425
IoT Platforms	426
▶ <b>APPLICATION CASE 8.3 Pitney Bowes Collaborates with General Electric IoT Platform to Optimize Production</b>	426
IoT Start-Up Ecosystem	427
Managerial Considerations in the Internet of Things	428
<b>8.3 Cloud Computing and Business Analytics</b>	<b>429</b>
Data as a Service (DaaS)	431
Software as a Service (SaaS)	432
Platform as a Service (PaaS)	432
Infrastructure as a Service (IaaS)	432
Essential Technologies for Cloud Computing	433
Cloud Deployment Models	433
Major Cloud Platform Providers in Analytics	434
Analytics as a Service (AaaS)	435
Representative Analytics as a Service Offerings	435
Illustrative Analytics Applications Employing the Cloud Infrastructure	436
▶ <b>MD Anderson Cancer Center Utilizes Cognitive Computing Capabilities of IBM Watson to Give Better Treatment to Cancer Patients</b>	436
▶ <b>Public School Education in Tacoma, Washington, Uses Microsoft Azure Machine Learning to Predict School Dropouts</b>	437
▶ <b>Dartmouth-Hitchcock Medical Center Provides Personalized Proactive Healthcare Using Microsoft Cortana Analytics Suite</b>	438
▶ <b>Mankind Pharma Uses IBM Cloud Infrastructure to Reduce Application Implementation Time by 98%</b>	438
▶ <b>Gulf Air Uses Big Data to Get Deeper Customer Insight</b>	439
▶ <b>Chime Enhances Customer Experience Using Snowflake</b>	440
<b>8.4 Location-Based Analytics for Organizations</b>	<b>441</b>
Geospatial Analytics	441
▶ <b>APPLICATION CASE 8.4 Great Clips Employs Spatial Analytics to Shave Time in Location Decisions</b>	443
▶ <b>APPLICATION CASE 8.5 Starbucks Exploits GIS and Analytics to Grow Worldwide</b>	444
Real-Time Location Intelligence	445
▶ <b>APPLICATION CASE 8.6 Quiznos Targets Customers for Its Sandwiches</b>	446
Analytics Applications for Consumers	446

<b>8.5 Issues of Legality, Privacy, and Ethics</b>	<b>448</b>
Legal Issues	448
Privacy	449
Collecting Information about Individuals	449
Mobile User Privacy	450
Homeland Security and Individual Privacy	450
Recent Technology Issues in Privacy and Analytics	451
Who Owns Our Private Data?	452
Ethics in Decision Making and Support	452
<b>8.6 Impacts of Analytics in Organizations: An Overview</b>	<b>453</b>
New Organizational Units	454
Redesign of an Organization through the Use of Analytics	455
Analytics Impact on Managers' Activities, Performance, and Job Satisfaction	455
Industrial Restructuring	456
Automation's Impact on Jobs	457
Unintended Effects of Analytics	458
<b>8.7 Data Scientist as a Profession</b>	<b>459</b>
Where Do Data Scientists Come From?	459
Chapter Highlights	462
Key Terms	463
Questions for Discussion	463
Exercises	463
References	464
Glossary	467
Index	475

This page intentionally left blank

# Preface

Analytics has become the technology driver of this decade. Companies such as IBM, SAP, IBM, SAS, Teradata, SAP, Oracle, Microsoft, Dell and others are creating new organizational units focused on analytics that help businesses become more effective and efficient in their operations. Decision makers are using more computerized tools to support their work. Even consumers are using analytics tools, either directly or indirectly, to make decisions on routine activities such as shopping, health/healthcare, travel, and entertainment. The field of business intelligence and business analytics (BI & BA) has evolved rapidly to become more focused on innovative applications for extracting knowledge and insight from data streams that were not even captured some time back, much less analyzed in any significant way. New applications turn up daily in healthcare, sports, travel, entertainment, supply-chain management, utilities, and virtually every industry imaginable. The term *analytics* has become mainstream. Indeed, it has already evolved into other terms such as data science, and the latest incarnation is deep learning and Internet of Things.

This edition of the text provides a managerial perspective to business analytics continuum beginning with descriptive analytics (e.g., the nature of data, statistical modeling, data visualization, and business intelligence), moving on to predictive analytics (e.g., data mining, text/web mining, social media mining), and then to prescriptive analytics (e.g., optimization and simulation), and finally finishing with Big Data, and future trends, privacy, and managerial considerations. The book is supported by a Web site ([pearsonhighered.com/sharda](http://pearsonhighered.com/sharda)) and also by an independent site at [dssbibook.com](http://dssbibook.com). We will also provide links to software tutorials through a special section of the Web sites.

The purpose of this book is to introduce the reader to these technologies that are generally called *business analytics* or *data science* but have been known by other names. This book presents the fundamentals of the techniques and the manner in which these systems are constructed and used. We follow an EEE approach to introducing these topics: **Exposure**, **Experience**, and **Exploration**. The book primarily provides **exposure** to various analytics techniques and their applications. The idea is that a student will be inspired to learn from how other organizations have employed analytics to make decisions or to gain a competitive edge. We believe that such **exposure** to what is being done with analytics and how it can be achieved is the key component of learning about analytics. In describing the techniques, we also introduce specific software tools that can be used for developing such applications. The book is not limited to any one software tool, so the students can **experience** these techniques using any number of available software tools. Specific suggestions are given in each chapter, but the student and the professor are able to use this book with many different software tools. Our book's companion Web site will include specific software guides, but students can gain **experience** with these techniques in many different ways. Finally, we hope that this **exposure** and **experience** enable and motivate readers to **explore** the potential of these techniques in their own domain. To facilitate such **exploration**, we include exercises that direct them to Teradata University Network and other sites as well that include team-oriented exercises where appropriate. We will also highlight new and innovative applications that we learn about on the book's Web site.

Most of the specific improvements made in this fourth edition concentrate on four areas: reorganization, new chapters, content update, and a sharper focus. Despite the many changes, we have preserved the comprehensiveness and user friendliness that have made the text a market leader. Finally, we present accurate and updated material that is not available in any other text. We next describe the changes in the fourth edition.

## What's New in the Fourth Edition?

With the goal of improving the text, this edition marks a major reorganization of the text to reflect the focus on business analytics. This edition is now organized around three major types of business analytics (i.e., descriptive, predictive, and prescriptive). The new edition has many timely additions, and the dated content has been deleted. The following major specific changes have been made.

- **New organization.** The book recognizes three types of analytics: descriptive, predictive, and prescriptive, a classification promoted by INFORMS. Chapter 1 introduces BI and analytics with an application focus in many industries. This chapter also includes an overview of the analytics ecosystem to help the user explore all the different ways one can participate and grow in the analytics environment. It is followed by an overview of statistics, importance of data, and descriptive analytics/visualization in Chapter 2. Chapter 3 covers data warehousing and data foundations including updated content, specifically data lakes. Chapter 4 covers predictive analytics. Chapter 5 extends the application of analytics to text, Web, and social media. Chapter 6 covers prescriptive analytics, specifically linear programming and simulation. It is totally new content for this book. Chapter 7 introduces Big Data tools and platforms. The book concludes with Chapter 8, emerging trends and topics in business analytics including location analytics, Internet of Things, cloud-based analytics, and privacy/ethical considerations in analytics. The discussion of an analytics ecosystem recognizes prescriptive analytics as well.
- **New chapters.** The following chapters have been added:

**Chapter 2. Descriptive Analytics I: Nature of Data, Statistical Modeling, and Visualization** This chapter aims to set the stage with a thorough understanding of the nature of data, which is the main ingredient for any analytics study. Next, statistical modeling is introduced as part of the descriptive analytics. Data visualization has become a popular part of any business reporting and/or descriptive analytics project; therefore, it is explained in detail in this chapter. The chapter is enhanced with several real-world cases and examples (75% new material).

### **Chapter 6. Prescriptive Analytics: Optimization and Simulation**

This chapter introduces prescriptive analytics material to this book. The chapter focuses on optimization modeling in Excel using linear programming techniques. It also introduces the concept of simulation. The chapter is an updated version of material from two chapters in our DSS book, 10th edition. For this book it is an entirely new chapter (99% new material).

**Chapter 8. Future Trends, Privacy and Managerial Considerations in Analytics** This chapter examines several new phenomena that are already changing or are likely to change analytics. It includes coverage of geospatial analytics, Internet of Things, and a significant update of the material on cloud-based analytics. It also updates some coverage from the last edition on ethical and privacy considerations (70% new material).

- **Revised Chapters.** All the other chapters have been revised and updated as well. Here is a summary of the changes in these other chapters:

**Chapter 1. An Overview of Business Intelligence, Analytics, and Data Science** This chapter has been rewritten and significantly expanded. It opens with a new vignette covering multiple applications of analytics in sports. It introduces the three types of analytics as proposed by INFORMS: descriptive, predictive, and prescriptive analytics. A noted earlier, this classification is used in

guiding the complete reorganization of the book itself (earlier content but with a new figure). Then it includes several new examples of analytics in healthcare and in the retail industry. Finally, it concludes with significantly expanded and updated coverage of the analytics ecosystem to give the students a sense of the vastness of the analytics and data science industry (about 60% new material).

**Chapter 3. *Descriptive Analytics II: Business Intelligence and Data Warehousing*** This is an old chapter with some new subsections (e.g., data lakes) and new cases (about 30% new material).

**Chapter 4. *Predictive Analytics I: Data Mining Process, Methods, and Algorithms*** This is an old chapter with some new content organization/flow and some new cases (about 20% new material).

**Chapter 5. *Predictive Analytics II: Text, Web, and Social Media Analytics*** This is an old chapter with some new content organization/flow and some new cases (about 25% new material).

**Chapter 7. *Big Data Concepts and Analysis*** This was Chapter 6 in the last edition. It has been updated with a new opening vignette and cases, coverage of Teradata Aster, and new material on alternative data (about 25% new material).

- **Revamped author team.** Building on the excellent content that has been prepared by the authors of the previous editions (Turban, Sharda, Delen, and King), this edition was revised primarily by Ramesh Sharda and Dursun Delen. Both Ramesh and Dursun have worked extensively in analytics and have industry as well as research experience.
- **Color print!** We are truly excited to have this book appear in color. Even the figures from previous editions have been redrawn to take advantage of color. Use of color enhances many visualization examples and also the other material.
- **A live, updated Web site.** Adopters of the textbook will have access to a Web site that will include links to news stories, software, tutorials, and even YouTube videos related to topics covered in the book. This site will be accessible at [dssbibook.com](http://dssbibook.com).
- **Revised and updated content.** Almost all the chapters have new opening vignettes that are based on recent stories and events. In addition, application cases throughout the book have been updated to include recent examples of applications of a specific technique/model. New Web site links have been added throughout the book. We also deleted many older product links and references. Finally, most chapters have new exercises, Internet assignments, and discussion questions throughout.
- **Links to Teradata University Network (TUN).** Most chapters include new links to TUN ([teradatauniversitynetwork.com](http://teradatauniversitynetwork.com)).
- **Book title.** As is already evident, the book's title and focus have changed substantially.
- **Software support.** The TUN Web site provides software support at no charge. It also provides links to free data mining and other software. In addition, the site provides exercises in the use of such software.

---

## The Supplement Package: [www.pearsonhighered.com/sharda](http://www.pearsonhighered.com/sharda)

A comprehensive and flexible technology-support package is available to enhance the teaching and learning experience. The following instructor and student supplements are available on the book's Web site, [pearsonhighered.com/sharda](http://pearsonhighered.com/sharda):

- **Instructor's Manual.** The Instructor's Manual includes learning objectives for the entire course and for each chapter, answers to the questions and exercises at the end

of each chapter, and teaching suggestions (including instructions for projects). The Instructor's Manual is available on the secure faculty section of [pearsonhighered.com/sharda](http://pearsonhighered.com/sharda).

- **Test Item File and TestGen Software.** The Test Item File is a comprehensive collection of true/false, multiple-choice, fill-in-the-blank, and essay questions. The questions are rated by difficulty level, and the answers are referenced by book page number. The Test Item File is available in Microsoft Word and in TestGen. Pearson Education's test-generating software is available from [www.pearsonhighered.com/irc](http://www.pearsonhighered.com/irc). The software is PC/MAC compatible and preloaded with all the Test Item File questions. You can manually or randomly view test questions and drag-and-drop to create a test. You can add or modify test-bank questions as needed. Our TestGens are converted for use in BlackBoard, WebCT, Moodle, D2L, and Angel. These conversions can be found on [pearsonhighered.com/sharda](http://pearsonhighered.com/sharda). The TestGen is also available in Respondus and can be found on [www.respondus.com](http://www.respondus.com).
- **PowerPoint slides.** PowerPoint slides are available that illuminate and build on key concepts in the text. Faculty can download the PowerPoint slides from [pearsonhighered.com/sharda](http://pearsonhighered.com/sharda).

---

## Acknowledgments

Many individuals have provided suggestions and criticisms since the publication of the first edition of this book. Dozens of students participated in class testing of various chapters, software, and problems and assisted in collecting material. It is not possible to name everyone who participated in this project, but our thanks go to all of them. Certain individuals made significant contributions, and they deserve special recognition.

First, we appreciate the efforts of those individuals who provided formal reviews of the first through third editions (school affiliations as of the date of review):

Ann Aksut, Central Piedmont Community College  
 Bay Arinze, Drexel University  
 Andy Borchers, Lipscomb University  
 Ranjit Bose, University of New Mexico  
 Marty Crossland, MidAmerica Nazarene University  
 Kurt Engemann, Iona College  
 Badie Farah, Eastern Michigan University  
 Gary Farrar, Columbia College  
 Jerry Fjermestad, New Jersey Institute of Technology  
 Christie M. Fuller, Louisiana Tech University  
 Martin Grossman, Bridgewater State College  
 Jahangir Karimi, University of Colorado, Denver  
 Huei Lee, Eastern Michigan University  
 Natalie Nazarenko, SUNY Fredonia  
 Joo Eng Lee-Partridge, Central Connecticut State University  
 Gregory Rose, Washington State University, Vancouver  
 Khawaja Saeed, Wichita State University  
 Kala Chand Seal, Loyola Marymount University  
 Joshua S. White, PhD, State University of New York Polytechnic Institute  
 Roger Wilson, Fairmont State University  
 Vincent Yu, Missouri University of Science and Technology  
 Fan Zhao, Florida Gulf Coast University



We also appreciate the efforts of those individuals who provided formal reviews of this text and our other DSS book—*Business Intelligence and Analytics: Systems for Decision Support*, 10th Edition, Pearson Education, 2013.

Second, several individuals contributed material to the text or the supporting material. Susan Baskin of Teradata and Dr. David Schrader provided special help in identifying new TUN and Teradata content for the book and arranging permissions for the same. Dr. Dave Schrader contributed the opening vignette for the book. This vignette also included material developed by Dr. Ashish Gupta of Auburn University and Gary Wilkerson of the University of Tennessee–Chattanooga. It will provide a great introduction to analytics. We also thank INFORMS for their permission to highlight content from *Interfaces*. We also recognize the following individuals for their assistance in developing this edition of the book: Pankush Kalgotra, Prasoon Mathur, Rupesh Agarwal, Shubham Singh, Nan Liang, Jacob Pearson, Kinsey Clemmer, and Evan Murette (all of Oklahoma State University). Their help for this edition is gratefully acknowledged. Teradata Aster team, especially Mark Ott, provided the material for the opening vignette for Chapter 7. Aster material in Chapter 7 is adapted from other training guides developed by John Thuma and Greg Bethardy. Dr. Brian LeClaire, CIO of Humana Corporation led with contributions of several real-life healthcare case studies developed by his team at Humana. Abhishek Rathi of vCreaTek contributed his vision of analytics in the retail industry. Dr. Rick Wilson's excellent exercises for teaching and practicing linear programming skills in Excel are also gratefully acknowledged. Matt Turck agreed to let us adapt his IoT ecosystem material. Ramesh also recognizes the copyediting assistance provided by his daughter, Ruchy Sharda Sen. In addition, the following former PhD students and research colleagues of ours have provided content or advice and support for the book in many direct and indirect ways:

Asil Oztekin, Universality of Massachusetts-Lowell  
 Enes Eryarsoy, Sehir University  
 Hamed Majidi Zolbanin, Ball State University  
 Amir Hassan Zadeh, Wright State University  
 Supavich (Fone) Pengnate, North Dakota State University  
 Christie Fuller, Boise State University  
 Daniel Asamoah, Wright State University  
 Selim Zaim, Istanbul Technical University  
 Nihat Kasap, Sabanci University

Third, for the previous edition, we acknowledge the contributions of Dave King (JDA Software Group, Inc.). Other major contributors to the previous edition include J. Aronson (University of Georgia), who was our coauthor, contributing to the data warehousing chapter; Mike Goul (Arizona State University), whose contributions were included in Chapter 1; and T. P. Liang (National Sun Yet-Sen University, Taiwan), who contributed material on neural networks in the previous editions. Judy Lang collaborated with all of us, provided editing, and guided us during the entire project in the first edition.

Fourth, several vendors cooperated by providing case studies and/or demonstration software for the previous editions: Acxiom (Little Rock, Arkansas), California Scientific Software (Nevada City, California), Cary Harwin of Catalyst Development (Yucca Valley, California), IBM (San Carlos, California), DS Group, Inc. (Greenwich, Connecticut), Gregory Piatetsky-Shapiro of KDnuggets.com, Gary Lynn of NeuroDimension Inc. (Gainesville, Florida), Palisade Software (Newfield, New York), Promised Land Technologies (New Haven, Connecticut), Salford Systems (La Jolla, California), Sense Networks (New York, New York), Gary Miner of StatSoft, Inc. (Tulsa, Oklahoma), Ward Systems Group, Inc. (Frederick, Maryland), Idea Fisher Systems, Inc. (Irving, California), and Wordtech Systems (Orinda, California).

Fifth, special thanks to the Teradata University Network and especially to Susan Baskin, Program Director; Hugh Watson, who started TUN; and Michael Goul, Barb Wixom, and Mary Gros for their encouragement to tie this book with TUN and for providing useful material for the book.

Finally, the Pearson team is to be commended: Samantha Lewis, who has worked with us on this revision and orchestrated the color rendition of the book; and the production team, Ann Pulido, and Revathi Viswanathan and staff at Cengage, who transformed the manuscript into a book.

We would like to thank all these individuals and corporations. Without their help, the creation of this book would not have been possible.

*R.S.*

*D.D.*

*E.T.*

---

Note that Web site URLs are dynamic. As this book went to press, we verified that all the cited Web sites were active and valid. Web sites to which we refer in the text sometimes change or are discontinued because companies change names, are bought or sold, merge, or fail. Sometimes Web sites are down for maintenance, repair, or redesign. Most organizations have dropped the initial "www" designation for their sites, but some still use it. If you have a problem connecting to a Web site that we mention, please be patient and simply run a Web search to try to identify the new site. Most times, the new site can be found quickly. We apologize in advance for this inconvenience.

## About the Authors

**Ramesh Sharda** (MBA, PhD, University of Wisconsin–Madison) is the Vice Dean for Research and Graduate Programs, Watson/ConocoPhillips Chair, and a Regents Professor of Management Science and Information Systems in the Spears School of Business at Oklahoma State University (OSU). He cofounded and directed OSU's PhD in Business for the Executives Program. About 200 papers describing his research have been published in major journals, including *Operations Research*, *Management Science*, *Information Systems Research*, *Decision Support Systems*, and the *Journal of MIS*. He cofounded the AIS SIG on Decision Support Systems and Knowledge Management (SIGDSA). Dr. Sharda serves on several editorial boards, including those of *Decision Sciences Journal*, *Decision Support Systems*, and *ACM Data Base*. He has authored and edited several textbooks and research books and serves as the coeditor of several Springer book series (Integrated Series in Information Systems, Operations Research/Computer Science Interfaces, and Annals of Information Systems) with Springer. He is also currently serving as the Executive Director of the Teradata University Network. His current research interests are in decision support systems, business analytics, and technologies for managing information overload.

**Dursun Delen** (PhD, Oklahoma State University) is the Spears Endowed Chair in Business Administration, Patterson Foundation Endowed Chair in Business Analytics, Director of Research for the Center for Health Systems Innovation, and Regents Professor of Management Science and Information Systems in the Spears School of Business at Oklahoma State University (OSU). Prior to his academic career, he worked for a privately owned research and consultancy company, Knowledge Based Systems Inc., in College Station, Texas, as a research scientist for 5 years, during which he led a number of decision support and other information systems–related research projects funded by several federal agencies including the Department of Defense (DoD), National Aeronautics and Space Administration (NASA), National Institute for Standards and Technology (NIST), Ballistic Missile Defense Organization (BMDO), and Department of Energy (DOE). Dr. Delen has published more than 100 peer-reviewed articles, some of which have appeared in major journals like *Decision Sciences*, *Decision Support Systems*, *Communications of the ACM*, *Computers and Operations Research*, *Computers in Industry*, *Journal of Production Operations Management*, *Artificial Intelligence in Medicine*, *International Journal of Medical Informatics*, *Expert Systems with Applications*, and *IEEE Wireless Communications*. He recently authored/coauthored seven textbooks in the broad areas of business analytics, data mining, text mining, business intelligence, and decision support systems. He is often invited to national and international conferences for keynote addresses on topics related to data/text mining, business analytics, decision support systems, business intelligence, and knowledge management. He served as the General Cochair for the Fourth International Conference on Network Computing and Advanced Information Management (September 2–4, 2008, in Seoul, South Korea) and regularly chairs, tracks, and mini-tracks at various information systems and analytics conferences. He is currently serving as Editor-in-Chief, Senior Editor, Associate Editor, or Editorial Board Member for more than a dozen academic journals. His research and teaching interests are in data and text mining, business analytics, decision support systems, knowledge management, business intelligence, and enterprise modeling.

**Efraim Turban** (MBA, PhD., University of California, Berkeley) is a Visiting Scholar at the Pacific Institute for Information System Management, University of Hawaii. Prior to this,

he was on the staff of several universities, including City University of Hong Kong; Lehigh University; Florida International University; California State University, Long Beach; Eastern Illinois University; and the University of Southern California. Dr. Turban is the author of more than 100 refereed papers published in leading journals, such as *Management Science*, *MIS Quarterly*, and *Decision Support Systems*. He is also the author of 20 books, including *Electronic Commerce: A Managerial Perspective* and *Information Technology for Management*. He is also a consultant to major corporations worldwide. Dr. Turban's current areas of interest are Web-based decision support systems, social commerce, and collaborative decision making.

# **BUSINESS INTELLIGENCE, ANALYTICS, AND DATA SCIENCE**

## **A MANAGERIAL PERSPECTIVE**

This book deals with a collection of computer technologies that support managerial work—essentially, decision making. These technologies have had a profound impact on corporate strategy, performance, and competitiveness. Collectively, these technologies are called *business intelligence*, *business analytics*, and *data science*. Although the evolution of the terms is discussed, these names are also used interchangeably. This book tells stories of how smart people are employing these techniques to improve performance, service, and relationships in business, government, and non-profit worlds.

This page intentionally left blank