THIRD EDITION

BUSINESS INTELLIGENCE

A MANAGERIAL PERSPECTIVE ON ANALYTICS

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.

Global Edition contributions by

Loveleen Gaur
Amity University, Noida

PEARSON

Boston Columbus Indianapolis New York San Francisco Upper Saddle River
Amsterdam Cape Town Dubai London Madrid Milan Munich Paris Montréal Toronto
Delhi Mexico City São Paulo Sydney Hong Kong Seoul Singapore Taipei Tokyo

BRIEF CONTENTS

Preface 17
About the Authors 23

Chapter 1 An Overview of Business Intelligence, Analytics, and Decision Support 27
Chapter 2 Data Warehousing 61
Chapter 3 Business Reporting, Visual Analytics, and Business Performance Management 119
Chapter 4 Data Mining 169
Chapter 5 Text and Web Analytics 225
Chapter 6 Big Data and Analytics 299
Chapter 7 Business Analytics: Emerging Trends and Future Impacts 351

Glossary 393
Index 401

CONTENTS

Preface 17
About the Authors 23

Chapter 1 An Overview of Business Intelligence, Analytics, and Decision Support 27

1.1 Opening Vignette: Magpie Sensing Employs Analytics to Manage a Vaccine Supply Chain Effectively and Safely 28
1.2 Changing Business Environments and Computerized Decision Support 30
The Business Pressures–Responses–Support Model 30
1.3 A Framework for Business Intelligence (BI) 32
Definitions of BI 32
A Brief History of BI 33
The Architecture of BI 34
The Origins and Drivers of BI 34
► **APPLICATION CASE 1.1 Sabre Helps Its Clients Through Dashboards and Analytics 35**
A Multimedia Exercise in Business Intelligence 36
1.4 Intelligence Creation, Use, and BI Governance 37
A Cyclical Process of Intelligence Creation and Use 37
Intelligence and Espionage 38
1.5 Transaction Processing Versus Analytic Processing 39
1.6 Successful BI Implementation 40
The Typical BI User Community 40
Appropriate Planning and Alignment with the Business Strategy 40
Real-Time, On-Demand BI Is Attainable 41
Developing or Acquiring BI Systems 42
Justification and Cost–Benefit Analysis 42
Security and Protection of Privacy 42
Integration of Systems and Applications 42
1.7 Analytics Overview 43
Descriptive Analytics 44
Predictive Analytics 44
► **APPLICATION CASE 1.2 Eliminating Inefficiencies at Seattle Children's Hospital 45**
► **APPLICATION CASE 1.3 Analysis at the Speed of Thought 46**
Prescriptive Analytics 46
► **APPLICATION CASE 1.4 *Moneyball*: Analytics in Sports and Movies 47**
► **APPLICATION CASE 1.5 Analyzing Athletic Injuries 48**
Analytics Applied to Different Domains 48

► APPLICATION CASE 1.6 **Industrial and Commercial Bank of China (ICBC) Employs Models to Reconfigure Its Branch Network 49**
Analytics or Data Science? 50
1.8 Brief Introduction to Big Data Analytics 51
What Is Big Data? 51
► APPLICATION CASE 1.7 **Gilt Groupe's Flash Sales Streamlined by Big Data Analytics** 52
1.9 Plan of the Book 53
1.10 Resources, Links, and the Teradata University Network Connection 55
Resources and Links 55
Vendors, Products, and Demos 55
Periodicals 55
The Teradata University Network Connection 55
The Book's Web Site 55
Key Terms 56
Questions for Discussion 56
Exercises 56
End-of-Chapter Application Case 57
References 59

Chapter 2 Data Warehousing 61
2.1 Opening Vignette: Isle of Capri Casinos Is Winning with Enterprise Data Warehouse 62
2.2 Data Warehousing Definitions and Concepts 64
What Is a Data Warehouse? 64
A Historical Perspective to Data Warehousing 64
Characteristics of Data Warehousing 66
Data Marts 67
Operational Data Stores 67
Enterprise Data Warehouses (EDW) 68
► APPLICATION CASE 2.1 **A Better Data Plan: Well-Established TELCOs Leverage Data Warehousing and Analytics to Stay on Top in a Competitive Industry 68**
Metadata 69
2.3 Data Warehousing Process Overview 70
► APPLICATION CASE 2.2 **Data Warehousing Helps MultiCare Save More Lives 71**
2.4 Data Warehousing Architectures 73
Alternative Data Warehousing Architectures 76
Which Architecture Is the Best? 79
2.5 Data Integration and the Extraction, Transformation, and Load (ETL) Processes 80
Data Integration 81
► APPLICATION CASE 2.3 **BP Lubricants Achieves BIGS Success 81**
Extraction, Transformation, and Load 83

2.6 Data Warehouse Development 85
► APPLICATION CASE 2.4 Things Go Better with Coke's Data Warehouse 86
Data Warehouse Development Approaches 88
► APPLICATION CASE 2.5 Starwood Hotels & Resorts Manages Hotel Profitability with Data Warehousing 89
Additional Data Warehouse Development Considerations 91
Representation of Data in Data Warehouse 92
Analysis of Data in Data Warehouse 93
OLAP Versus OLTP 93
OLAP Operations 94
2.7 Data Warehousing Implementation Issues 97
► APPLICATION CASE 2.6 EDW Helps Connect State Agencies in Michigan 99
Massive Data Warehouses and Scalability 100
2.8 Real-Time Data Warehousing 101
► APPLICATION CASE 2.7 Egg Plc Fries the Competition in Near Real Time 102
2.9 Data Warehouse Administration, Security Issues, and Future Trends 105
The Future of Data Warehousing 107
2.10 Resources, Links, and the Teradata University Network Connection 110
Resources and Links 110
Cases 110
Vendors, Products, and Demos 111
Periodicals 111
Additional References 111
The Teradata University Network (TUN) Connection 111
Key Terms 112
Questions for Discussion 112
Exercises 113
End-of-Chapter Application Case 114
References 116

Chapter 3 Business Reporting, Visual Analytics, and Business Performance Management 119

3.1 Opening Vignette: Self-Service Reporting Environment Saves Millions for Corporate Customers 120
3.2 Business Reporting Definitions and Concepts 123
What Is a Business Report? 124
► APPLICATION CASE 3.1 Delta Lloyd Group Ensures Accuracy and Efficiency in Financial Reporting 126
Components of Business Reporting Systems 127
► APPLICATION CASE 3.2 Flood of Paper Ends at FEMA 128

3.3 Data and Information Visualization 129
► **APPLICATION CASE 3.3 Tableau Saves Blastrac Thousands of Dollars with Simplified Information Sharing 130**
A Brief History of Data Visualization 131
► **APPLICATION CASE 3.4 TIBCO Spotfire Provides Dana-Farber Cancer Institute with Unprecedented Insight into Cancer Vaccine Clinical Trials 133**
3.4 Different Types of Charts and Graphs 134
Basic Charts and Graphs 134
Specialized Charts and Graphs 135
3.5 The Emergence of Data Visualization and Visual Analytics 138
Visual Analytics 140
High-Powered Visual Analytics Environments 140
3.6 Performance Dashboards 143
Dashboard Design 145
► **APPLICATION CASE 3.5 Dallas Cowboys Score Big with Tableau and Teknion 145**
► **APPLICATION CASE 3.6 Saudi Telecom Company Excels with Information Visualization 146**
What to Look For in a Dashboard 148
Best Practices in Dashboard Design 148
Benchmark Key Performance Indicators with Industry Standards 149
Wrap the Dashboard Metrics with Contextual Metadata 149
Validate the Dashboard Design by a Usability Specialist 149
Prioritize and Rank Alerts/Exceptions Streamed to the Dashboard 149
Enrich Dashboard with Business-User Comments 149
Present Information in Three Different Levels 149
Pick the Right Visual Construct Using Dashboard Design Principles 150
Provide for Guided Analytics 150
3.7 Business Performance Management 150
Closed-Loop BPM Cycle 150
► **APPLICATION CASE 3.7 IBM Cognos Express Helps Mace for Faster and Better Business Reporting 153**
3.8 Performance Measurement 154
Key Performance Indicator (KPI) 154
Performance Measurement System 155
3.9 Balanced Scorecards 156
The Four Perspectives 156
The Meaning of Balance in BSC 158
Dashboards Versus Scorecards 159
3.10 Six Sigma as a Performance Measurement System 159
The DMAIC Performance Model 160
Balanced Scorecard Versus Six Sigma 160
Effective Performance Measurement 160

► **APPLICATION CASE 3.8 Expedia.com's Customer Satisfaction Scorecard 162**
Key Terms 164
Questions for Discussion 165
Exercises 165
End-of-Chapter Application Case 166
References 168

Chapter 4 Data Mining 169

4.1 Opening Vignette: Cabela's Reels in More Customers with Advanced Analytics and Data Mining 170
4.2 Data Mining Concepts and Applications 172
Definitions, Characteristics, and Benefits 173
► **APPLICATION CASE 4.1 Smarter Insurance: Infinity P&C Improves Customer Service and Combats Fraud with Predictive Analytics 174**
How Data Mining Works 179
► **APPLICATION CASE 4.2 Harnessing Analytics to Combat Crime: Predictive Analytics Helps Memphis Police Department Pinpoint Crime and Focus Police Resources 179**
Data Mining Versus Statistics 183
4.3 Data Mining Applications 183
► **APPLICATION CASE 4.3 A Mine on Terrorist Funding 186**
4.4 Data Mining Process 187
Step 1: Business Understanding 187
Step 2: Data Understanding 188
Step 3: Data Preparation 188
Step 4: Model Building 190
Step 5: Testing and Evaluation 192
Step 6: Deployment 192
► **APPLICATION CASE 4.4 Data Mining in Cancer Research 193**
Other Data Mining Standardized Processes and Methodologies 194
4.5 Data Mining Methods 196
Classification 196
Estimating the True Accuracy of Classification Models 197
► **APPLICATION CASE 4.5 2degrees Gets a 1275 Percent Boost in Churn Identification 203**
Cluster Analysis for Data Mining 204
Association Rule Mining 206
4.6 Data Mining Software Tools 210
► **APPLICATION CASE 4.6 Data Mining Goes to Hollywood: Predicting Financial Success of Movies 213**
4.7 Data Mining Privacy Issues, Myths, and Blunders 216
Data Mining and Privacy Issues 216
► **APPLICATION CASE 4.7 Predicting Customer Buying Patterns—The Target Story 217**

Data Mining Myths and Blunders 218
Key Terms 220
Questions for Discussion 220
Exercises 221
End-of-Chapter Application Case 223
References 223

Chapter 5 Text and Web Analytics 225

5.1 Opening Vignette: Machine Versus Men on *Jeopardy!*: The Story of Watson 226

5.2 Text Analytics and Text Mining Overview 229

▶ **APPLICATION CASE 5.1 Text Mining for Patent Analysis 232**

5.3 Natural Language Processing 233

▶ **APPLICATION CASE 5.2 Text Mining Improves Hong Kong Government's Ability to Anticipate and Address Public Complaints 235**

5.4 Text Mining Applications 237

Marketing Applications 238

Security Applications 238

▶ **APPLICATION CASE 5.3 Mining for Lies 239**

Biomedical Applications 241

Academic Applications 242

▶ **APPLICATION CASE 5.4 Text mining and Sentiment Analysis Help Improve Customer Service Performance 243**

5.5 Text Mining Process 244

Task 1: Establish the Corpus 245

Task 2: Create the Term–Document Matrix 246

Task 3: Extract the Knowledge 248

▶ **APPLICATION CASE 5.5 Research Literature Survey with Text Mining 250**

5.6 Sentiment Analysis 253

▶ **APPLICATION CASE 5.6 Whirlpool Achieves Customer Loyalty and Product Success with Text Analytics 255**

Sentiment Analysis Applications 256

Sentiment Analysis Process 258

Methods for Polarity Identification 259

Using a Lexicon 260

Using a Collection of Training Documents 261

Identifying Semantic Orientation of Sentences and Phrases 261

Identifying Semantic Orientation of Document 261

5.7 Web Mining Overview 262

Web Content and Web Structure Mining 264

5.8 Search Engines 267

Anatomy of a Search Engine 267

Development Cycle 267

Web Crawler 268
Document Indexer 268
Response Cycle 269
Query Analyzer 269
Document Matcher/Ranker 269
Search Engine Optimization 270
Methods for Search Engine Optimization 271
► **APPLICATION CASE 5.7 Understanding Why Customers Abandon Shopping Carts Results in a $10 Million Sales Increase 272**
5.9 Web Usage Mining (Web Analytics) 274
Web Analytics Technologies 274
► **APPLICATION CASE 5.8 Allegro Boosts Online Click-Through Rates by 500 Percent with Web Analysis 275**
Web Analytics Metrics 277
Web Site Usability 277
Traffic Sources 278
Visitor Profiles 229
Conversion Statistics 280
5.10 Social Analytics 281
Social Network Analysis 282
Social Network Analysis Metrics 283
► **APPLICATION CASE 5.9 Social Network Analysis Helps Telecommunication Firms 283**
Connections 284
Distributions 285
Segmentation 285
Social Media Analytics 285
How Do People Use Social Media? 286
► **APPLICATION CASE 5.10 Measuring the Impact of Social Media at Lollapalooza 287**
Measuring the Social Media Impact 288
Best Practices in Social Media Analytics 289
► **APPLICATION CASE 5.11 eHarmony Uses Social Media to Help Take the Mystery Out of Online Dating 290**
Key Terms 293
Questions for Discussion 293
Exercises 293
End-of-Chapter Application Case 294
References 296

Chapter 6 Big Data and Analytics 299
6.1 Opening Vignette: Big Data Meets Big Science at CERN 300
6.2 Definition of Big Data 303
The Vs That Define Big Data 304
► **APPLICATION CASE 6.1 BigData Analytics Helps Luxottica Improvement its Marketing Effectiveness 307**

6.3 Fundamentals of Big Data Analytics 308
Business Problems Addressed by Big Data Analytics 311
► **APPLICATION CASE 6.2 Top 5 Investment Bank Achieves Single Source of the Truth 312**
6.4 Big Data Technologies 313
MapReduce 313
Why Use MapReduce? 315
Hadoop 315
How Does Hadoop Work? 315
Hadoop Technical Components 316
Hadoop: The Pros and Cons 317
NoSQL 319
► **APPLICATION CASE 6.3 eBay's Big Data Solution 320**
6.5 Data Scientist 321
Where Do Data Scientists Come From? 322
► **APPLICATION CASE 6.4 Big Data and Analytics in Politics 325**
6.6 Big Data and Data Warehousing 326
Use Cases for Hadoop 327
Use Cases for Data Warehousing 328
The Gray Areas (Any One of the Two Would Do the Job) 329
Coexistence of Hadoop and Data Warehouse 329
6.7 Big Data Vendors 331
► **APPLICATION CASE 6.5 Dublin City Council Is Leveraging Big Data to Reduce Traffic Congestion 333**
► **APPLICATION CASE 6.6 Creditreform Boosts Credit Rating Quality with Big Data Visual Analytics 337**
6.8 Big Data And Stream Analytics 338
Stream Analytics Versus Perpetual Analytics 339
Critical Event Processing 340
Data Stream Mining 341
6.9 Applications of Stream Analytics 341
e-Commerce 341
Telecommunications 342
► **APPLICATION CASE 6.7 Turning Machine-Generated Streaming Data into Valuable Business Insights 342**
Law Enforcement and Cyber Security 344
Power Industry 344
Financial Services 344
Health Sciences 344
Government 345
Key Terms 346
Questions for Discussion 346

Exercises 346
End-of-Chapter Application Case 347
References 348

Chapter 7 Business Analytics: Emerging Trends and Future Impacts 351

7.1 Opening Vignette: Oklahoma Gas and Electric Employs Analytics to Promote Smart Energy Use 352

7.2 Location-Based Analytics for Organizations 353

Geospatial Analytics 353

► **APPLICATION CASE 7.1 Great Clips Employs Spatial Analytics to Shave Time in Location Decisions 355**

Real-Time Location Intelligence 357

► **APPLICATION CASE 7.2 Quiznos Targets Customers for its Sandwiches 358**

7.3 Analytics Applications for Consumers 359

► **APPLICATION CASE 7.3 A Life Coach in Your Pocket 360**

7.4 Recommendation Engines 362

7.5 The Web 2.0 Revolution and Online Social Networking 363

Representative Characteristics of Web 2.0 364

Social Networking 364

A Definition and Basic Information 365

Implications of Business and Enterprise Social Networks 365

7.6 Cloud Computing and BI 366

Service-Oriented DSS 367

Data-as-a-Service (DaaS) 369

Information-as-a-Service (Information on Demand) (IaaS) 370

Analytics-as-a-Service (AaaS) 371

7.7 Impacts of Analytics In Organizations: An Overview 372

New Organizational Units 373

Restructuring Business Processes and Virtual Teams 373

Job Satisfaction 374

Job Stress and Anxiety 374

Analytics' Impact on Managers' Activities and Their Performance 374

7.8 Issues of Legality, Privacy, and Ethics 376

Legal Issues 376

Privacy 376

Recent Technology Issues in Privacy and Analytics 376

Ethics in Decision Making and Support 379

7.9 An Overview of the Analytics Ecosystem 379

Analytics Industry Clusters 380

Data Infrastructure Providers 380

Data Warehouse Industry 381

Middleware/BI Platform Industry 381

Data Aggregators/Distributors 382
Analytics-Focused Software Developers 382
Reporting/Analytics 382
Predictive Analytics 382
Prescriptive Analytics 383
Application Developers or System Integrators: Industry Specific or General 383
Analytics User Organizations 385
Analytics Industry Analysts and Influencers 385
Academic Providers and Certification Agencies 387
Key Terms 389
Questions for Discussion 389
Exercises 389
End-of-Chapter Application Case 390
References 391
Glossary 393
Index 401