INTRODUCTION TO
OPERATIONS AND
SUPPLY CHAIN
MANAGEMENT

Cecil C. Bozarth
North Carolina State University

Robert B. Handfield
North Carolina State University

Pearson
New York, NY
To Andrea, James, and Philip

C.B.

To Sandi, Simone, and Luc

R.H.
Cecil Bozarth is Professor of Operations and Supply Chain Management at the Poole College of Management at N.C. State University, where he has received awards for teaching excellence at both the undergraduate and graduate levels. He is a former chair of the Operations Management Division of the Academy of Management, and in 1999 was recognized by APICS as a subject matter expert (SME) in the area of supply chain management. His particular areas of interest are operations and supply chain strategy and supply chain information systems. Cecil’s consulting experience cuts across a wide range of industries, including such companies as BlueCross BlueShield of North Carolina, Daimler-Benz, John Deere, Duke Energy, Eisai, Ford Motor Company, GKN, IBM, GlaxoSmithKline, Milliken, Patheon, Sonoco, and others. For thirteen years, Cecil was an associate editor for the Journal of Operations Management; he now serves on the journal’s editorial advisory board. Cecil has also served as a guest editor for the Academy of Management Journal, as well as the Journal of Operations Management.

Robert Handfield is the Bank of America Professor and a Distinguished University Professor at N.C. State University. Handfield has consulted with over 25 Fortune 500 companies, including Biogen Idec, Caterpillar, John Deere, GlaxoSmithKline, Boston Scientific, Delphi, Chevron, British Petroleum, Chevron Phillips, Bank of America, Sensata, Honda of America, KPMG, Conoco Phillips, Federal Express, SAP, and others, and is a world-renowned expert in the areas of purchasing and logistics. Rob is the former editor-in-chief of the Journal of Operations Management and has written several books on SCM topics, including Introduction to Supply Chain Management (Prentice Hall, with Ernest L. Nichols; translated into Japanese, Korean, Chinese, and Indonesian), Supply Chain Redesign (Prentice Hall Financial Times), and Purchasing and Supply Chain Management, 5th edition (South-Western College Publishing, with Robert M. Monczka, Larry C. Giunipero, and James L. Patterson).
# BRIEF CONTENTS

Preface xi

## PART I CREATING VALUE THROUGH OPERATIONS AND SUPPLY CHAINS 1

<table>
<thead>
<tr>
<th>Chapter</th>
<th>Title</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Introduction to Operations and Supply Chain Management</td>
<td>1</td>
</tr>
<tr>
<td>2</td>
<td>Operations and Supply Chain Strategies</td>
<td>20</td>
</tr>
</tbody>
</table>

## PART II ESTABLISHING THE OPERATIONS ENVIRONMENT 40

<table>
<thead>
<tr>
<th>Chapter</th>
<th>Title</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>Process Choice and Layout Decisions in Manufacturing and Services</td>
<td>40</td>
</tr>
<tr>
<td>4</td>
<td>Business Processes</td>
<td>74</td>
</tr>
<tr>
<td>5</td>
<td>Managing Quality</td>
<td>108</td>
</tr>
<tr>
<td>6</td>
<td>Managing Capacity</td>
<td>142</td>
</tr>
<tr>
<td>6S</td>
<td>Advanced Waiting Line Theory and Simulation Modeling</td>
<td>175</td>
</tr>
</tbody>
</table>

## PART III ESTABLISHING SUPPLY CHAIN LINKAGES 189

<table>
<thead>
<tr>
<th>Chapter</th>
<th>Title</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>7</td>
<td>Supply Management</td>
<td>189</td>
</tr>
<tr>
<td>8</td>
<td>Logistics</td>
<td>221</td>
</tr>
</tbody>
</table>

## PART IV PLANNING AND CONTROLLING OPERATIONS AND SUPPLY CHAINS 254

<table>
<thead>
<tr>
<th>Chapter</th>
<th>Title</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>9</td>
<td>Forecasting</td>
<td>254</td>
</tr>
<tr>
<td>10</td>
<td>Sales and Operations Planning (Aggregate Planning)</td>
<td>299</td>
</tr>
<tr>
<td>11</td>
<td>Managing Inventory throughout the Supply Chain</td>
<td>331</td>
</tr>
<tr>
<td>12</td>
<td>Managing Production across the Supply Chain</td>
<td>364</td>
</tr>
<tr>
<td>12S</td>
<td>Supply Chain Information Systems</td>
<td>399</td>
</tr>
<tr>
<td>13</td>
<td>JIT/Lean Production</td>
<td>408</td>
</tr>
</tbody>
</table>

## PART V PROJECT MANAGEMENT AND PRODUCT/SERVICE DEVELOPMENT 429

<table>
<thead>
<tr>
<th>Chapter</th>
<th>Title</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>14</td>
<td>Managing Projects</td>
<td>429</td>
</tr>
<tr>
<td>15</td>
<td>Developing Products and Services</td>
<td>451</td>
</tr>
</tbody>
</table>

Appendices 469
Glossary 475
Index 487
CONTENTS

Preface xi

PART I

Creating Value through Operations and Supply Chains 1

1 Introduction to Operations and Supply Chain Management 1

Introduction 2

1.1 Why Study Operations and Supply Chain Management? 3

Operations Management 4

Supply Chain Management 6

1.2 Important Trends 9

Agility 10

Information Technologies 10

People 10

1.3 Operations and Supply Chain Management and You 11

Professional Organizations 12

Cross-Functional and Interorganizational Linkages 13

1.4 Employability Skills 14

Critical Thinking 14

Collaboration 15

Knowledge Application and Analysis 15

Information Technology Application and Computing Skills 15

1.5 Purpose and Organization of This Book 15

Chapter Summary 17

Key Terms 17

Discussion Questions 17

Problems 17

Case Study 18

References 19

2 Operations and Supply Chain Strategies 20

Introduction 22

2.1 Elements of the Business 22

2.2 Strategy 22

2.3 Operations and Supply Chain Strategies 25

Customer Value 26

Four Performance Dimensions 27

Trade-Offs among Performance Dimensions 29

Order Winners and Order Qualifiers 29

Stages of Alignment with the Business Strategy 30

Core Competencies in Operations and Supply Chains 32

Chapter Summary 33

Key Formula 34

Key Terms 34

Solved Problem 34

PART II

Establishing the Operations Environment 40

3 Process Choice and Layout Decisions in Manufacturing and Services 40

Introduction 41

3.1 Manufacturing Processes 42

Production Lines and Continuous Flow Manufacturing 43

Job Shops 44

Batch Manufacturing 45

Fixed-Position Layout 45

Hybrid Manufacturing Processes 45

3D Printing 46

Linking Manufacturing Processes across the Supply Chain 47

Selecting a Manufacturing Process 47

The Product-Process Matrix 47

3.2 Product Customization within the Supply Chain 48

Four Levels of Customization 48

The Customization Point 48

3.3 Service Processes 51

Service Packages 52

Service Customization 52

Customer Contact 53

Service Positioning 56

Services within the Supply Chain 57

3.4 Layout Decision Models 58

Line Balancing 59

Assigning Department Locations in Functional Layouts 62

Chapter Summary 66

Key Formulas 66

Key Terms 67

Solved Problem 67

Discussion Questions 69

Problems 70

Case Study 72

References 73

4 Business Processes 74

Introduction 75

4.1 Business Processes 76

Improving Business Processes 76

4.2 Mapping Business Processes 79

Process Maps 79

Swim Lane Process Maps 82
CONTENTS

7.4 Trends in Supply Management 213
    Sustainable Supply 213
    Supply Chain Disruptions 214
Chapter Summary 215
Key Formulas 215
Key Terms 215
Solved Problem 216
Discussion Questions 217
Problems 217
Case Study 219
References 220

8 Logistics 221

Introduction 223
8.1 Why Logistics Is Critical 223
8.2 Logistics Decision Areas 225
    Transportation 225
    Selecting a Transportation Mode 226
    Multimodal Solutions 227
    Warehousing 228
    Logistics Information Systems 231
    Material Handling and Packaging 233
    Inventory Management 234
8.3 Logistics Strategy 234
    Owning versus Outsourcing 235
    Measuring Logistics Performance 236
    Landed Costs 237
    Reverse Logistics Systems 238
8.4 Logistics Decision Models 239
    Weighted Center of Gravity Method 239
    Optimization Models 241
Chapter Summary 246
Key Formulas 247
Key Terms 247
Solved Problem 248
Discussion Questions 249
Problems 250
Case Study 252
References 253

PART IV

Planning and Controlling Operations and Supply Chains 254

9 Forecasting 254

Introduction 255
9.1 Forecast Types 256
    Demand Forecasts 256
    Supply Forecasts 256
    Price Forecasts 256
9.2 Laws of Forecasting 257
    Law 1: Forecasts Are Almost Always Wrong (But They Are Still Useful) 258
    Law 2: Forecasts for the Near Term Tend to Be More Accurate 258
Law 3: Forecasts for Groups of Products or Services Tend to Be More Accurate 258
Law 4: Forecasts Are No Substitute for Calculated Values 258
9.3 Selecting a Forecasting Method 258
9.4 Qualitative Forecasting Methods 259
9.5 Time Series Forecasting Models 260
    Last Period 261
    Moving Average 262
    Weighted Moving Average 264
    Exponential Smoothing 264
    Adjusted Exponential Smoothing 267
    Linear Regression 268
    Seasonal Adjustments 272
9.6 Causal Forecasting Models 276
    Linear Regression 276
    Multiple Regression 278
9.7 Measures of Forecast Accuracy 281
9.8 Computer-Based Forecasting Packages 283
9.9 Collaborative Planning, Forecasting, and Replenishment (CPFR) 283
Chapter Summary 288
Key Formulas 288
Key Terms 290
Solved Problem 290
Discussion Questions 293
Problems 293
Case Study 297
References 298

10 Sales and Operations Planning (Aggregate Planning) 299

Introduction 300
10.1 S&OP in the Planning Cycle 300
10.2 Major Approaches to S&OP 302
    Top-Down Planning 303
    Level, Chase, and Mixed Production Plans 305
    Bottom-Up Planning 309
    Cash Flow Analysis 311
10.3 Organizing for and Implementing S&OP 313
    Choosing between Alternative Plans 313
    Rolling Planning Horizons 314
    Implementing S&OP in an Organization 315
10.4 Services Considerations 316
    Making Sales Match Capacity 316
    Making Capacity Match Sales 318
10.5 Linking S&OP throughout the Supply Chain 319
10.6 Applying Optimization Modeling to S&OP 319
Chapter Summary 323
Key Formulas 323
Key Terms 323
Solved Problem 323
Discussion Questions 325
Problems 325
Case Study 329
References 330
11 Managing Inventory throughout the Supply Chain 331

Introduction 333
11.1 The Role of Inventory 334
Infomation Types 334
Inventory Drivers 336
Independent versus Dependent Demand Inventory 338
11.2 Periodic Review Systems 338
Restocking Levels 339
11.3 Continuous Review Systems 340
The Economic Order Quantity (EOQ) 341
Reorder Points and Safety Stock 343
Quantity Discounts 346
11.4 Single-Period Inventory Systems 348
Target Service Level 348
Target Stocking Point 350
11.5 Inventory in the Supply Chain 352
The Bullwhip Effect 352
Inventory Positioning 353
Transportation, Packaging, and Material Handling Considerations 354
Chapter Summary 355
Key Formulas 355
Key Terms 356
Using Excel in Inventory Management 356
Solved Problem 357
Discussion Questions 358
Problems 358
Case Study 362
References 363

12 Managing Production across the Supply Chain 364

Introduction 365
12.1 Master Scheduling 366
The Master Schedule Record 367
Using the Master Schedule 372
12.2 Material Requirements Planning 373
The MRP Record 375
The Advantages of MRP 380
Special Considerations in MRP 380
12.3 Production Activity Control and Vendor Order Management Systems 382
Job Sequencing 382
Monitoring and Tracking Technologies 383
12.4 Synchronizing Planning and Control across the Supply Chain 384
Distribution Requirements Planning 384
Chapter Summary 387
Key Formulas 389
Key Terms 389
Solved Problem 390
Discussion Questions 390
Problems 391
Case Study 398
References 398

12S Supply Chain Information Systems 399

Introduction 400
12S.1 Understanding Supply Chain Information Needs 401
Differences across Organizational Levels 401
Direction of Linkages 402
12S.2 Supply Chain Information Systems 402
12S.3 Trends to Watch 405
BPM Tools 405
Cloud Computing 405
Internet of Things (IoT) 406
Supplement Summary 406
Key Terms 407
Discussion Questions 407
References 407

13 JIT/Lean Production 408

Introduction 410
13.1 The Lean Perspective on Waste 411
13.2 The Lean Perspective on Inventory 412
13.3 Recent Developments in Lean Thinking 413
13.4 Kanban Systems 414
Controlling Inventory Levels Using Kanbans 419
Synchronizing the Supply Chain Using Kanbans 421
Using MRP and Kanban Together 422
Chapter Summary 423
Key Formula 423
Key Terms 424
Solved Problem 424
Discussion Questions 425
Problems 425
Case Study 426
References 428

PART V Project Management and Product/Service Development 429

14 Managing Projects 429

Introduction 430
14.1 The Growing Importance of Project Management 431
14.2 Project Phases 432
Concept Phase 432
Project Definition Phase 432
Planning Phase 433
Performance Phase 433
Postcompletion Phase 433
14.3 Project Management Tools 434
Gantt Charts 434
Network Diagrams 436
Constructing a Network Diagram 436
Crashing a Project 440
References 440
CONTENTS

14.4 Project Management Software 442
14.5 PMI and the Project Management Body of Knowledge (PMBOK®) 445

Chapter Summary 445
Key Formulas 445
Key Terms 446
Solved Problem 446
Discussion Questions 447
Problems 448
Case Study 450
References 450

15 Developing Products and Services 451

Introduction 453
Product Design and the Development Process 453
Four Reasons for Developing New Products and Services 453
15.1 Operations and Supply Chain Perspectives on Design 454
Repeatability, Testability, and Serviceability 455
Production Volumes 455
Product Costs 455
Match with Existing Capabilities 456
15.2 The Development Process 457
A Model of the Development Process 457
Sequential Development versus Concurrent Engineering 459
15.3 Organizational Roles in Product and Service Development 460
Engineering 460
Marketing 460
Accounting 460
Finance 460
Designers 461
Purchasing 461
Suppliers 462
Who Leads? 462
15.4 Approaches to Improving Product and Service Designs 462
DMADV (Define–Measure–Analyze–Design–Verify) 462
Quality Function Deployment (QFD) 463
Computer-Aided Design (CAD) and Computer-Aided Design/Computer-Aided Manufacturing (CAD/CAM) 464
The "Design for . . . " Approaches 464
Target Costing and Value Analysis 466

Chapter Summary 466
Key Terms 467
Discussion Questions 467
Case Study 467
References 468

Appendices 469
Glossary 475
Index 487
When we set out to write the first edition of this book, we wanted to create an introductory text that provides an integrated and comprehensive treatment of both operations and supply chain management. That goal has remained the same through this, our fifth, edition.

NEW TO THIS EDITION

PROFESSIONAL PROFILE

Mandy Althoff, MetLife
MetLife is a well-respected financial services company that provides life, annuities, automobile, disability, and asset management services. Whereas MetLife faces some uncertainty about the return on the financial risk in exchange for the premiums paid by the customer, found business practice and regulatory requirements dictate that MetLife keep enough cash reserves to pay off expected claims by the customers. To summarize this, MetLife makes good business sense for MetLife to execute business plans by using its expertise and strategic resources of the company. A key part of the MetLife’s strategy is to mitigate the risk and to focus on the financial image. This requires MetLife to perform most of the financial analysis, someone else in the market can handle the annual report. MetLife’s annual report has two parts. One is the ideas of having someone else handle the annual report and the second part is the ideas of having someone else handle the annual report. MetLife has a unique combination of these two techniques. We will look at the annual report and we will look at the MetLife's annual report.

PROFESSIONAL PROFILE

Dwight Hendrickson, Caterpillar
Throughout this book, we have made the point that supply chain management is seen as the entire supply chain from sourcing to producing to delivering the final product or service. Furthermore, supply chain management takes place at the strategic planning level, looking toward the future, down to the execution of day-to-day activities. In the past 20 years, Dwight Hendrickson has worked as a consultant to many firms. He has been a commercial purchasing analyst and a sales manager. He has held positions in several operations areas and has helped to lead the development of a new supply chain management course at the University of Maryland. Dwight Hendrickson’s expertise is in supply chain management. He currently serves on the North Carolina State University’s Board of Advisors, which is made up of professionals who act as consultants to small and medium-sized businesses that want to improve their supply chain management practices.

SOLVING TEACHING AND LEARNING CHALLENGES

Instructors teaching operations and supply chain management face several challenges. The first is helping students make the connection between the needs of the business and the tools and techniques operations covered in the book. A second challenge is deciding exactly what tools and techniques to cover, especially in an introductory course. Finally, some of the more quantitative tools can be quite complex, requiring a variety of learning approaches to help students master them. This book addresses these challenges in the following manner:

• The book contains comprehensive coverage of the tools and techniques in the traditional OM areas (quality, capacity, queuing, forecasting, inventory, planning and control, and project management), as well as the purchasing and logistics areas.
• Tools and techniques are always introduced within the context of the OM and SCM issues at hand. For example, we show how sales and operations planning (Chapter 10) can be used to coordinate activity across supply chain partners, as well as in its traditional role as an intra-firm planning approach.

• In addition to the extensive use of solved problems, students are shown how tools and techniques can be applied using Microsoft Excel spreadsheets. Learning is reinforced through homework problems that provide the students with a template and hints for checking their answers.

• An Enhanced eText, available in MyLab Operations Management, gives instructors and students the ability to highlight the text, bookmark, search the glossary, and take notes. More importantly, the eText provides a new way of learning that is particularly useful to today’s students. Students are able to review animations of figures, indicated by MyLab Operations Management Animation, and videos of solved problems available on MyLab Operations Management with a simple click of an icon. Visit www.pearson.com/mylab/operations-management for more information.
# Tools and Techniques Integrated Throughout

<table>
<thead>
<tr>
<th>Tools and Techniques</th>
<th>SOLVED EXAMPLES</th>
<th>HOMEWORK PROBLEMS</th>
<th>EXCEL EXAMPLES/PROBLEMS</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Chapter 2: Operations and Supply Chain Strategies</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Value index</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td><strong>Chapter 3: Process Choice and Layout Decisions in Manufacturing and Services</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Service blueprint</td>
<td>✓</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Line balancing</td>
<td>✓</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>Assigning department locations</td>
<td>✓</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td><strong>Chapter 4: Business Processes</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Performance measures (productivity, efficiency, cycle time, percent value-added time)</td>
<td>✓</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>Process mapping</td>
<td>✓</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>Six Sigma methodology and DMAIC process</td>
<td>✓</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Continuous improvement tools (root cause analysis, scatter plots, check sheets, Pareto charts)</td>
<td>✓</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>Cause-and-effect diagrams</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Chapter 5: Managing Quality</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Process capability ratio</td>
<td>✓</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>Process capability index</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Six Sigma quality</td>
<td>✓</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>X and R charts</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>( \rho ) charts</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Acceptance sampling</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Chapter 6: Managing Capacity</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Expected value analysis</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Decision trees</td>
<td>✓</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>Break-even analysis</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Indifference point</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Learning curves</td>
<td>✓</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>Theory of constraints</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Waiting lines (queueing analysis)</td>
<td>✓</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Little's Law</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Simulation analysis</td>
<td>✓</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Chapter 7: Supply Management</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total cost analysis</td>
<td>✓</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Weighted-point evaluation system</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Profit leverage</td>
<td>✓</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Spend analysis</td>
<td>✓</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Chapter 8: Logistics</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Shipment consolidation</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Perfect order calculation</td>
<td>✓</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Landed costs</td>
<td>✓</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Weighted center of gravity model</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Optimization modeling (assignment problem using Excel Solver function)</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td><strong>Chapter 9: Forecasting</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Moving average model</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Exponential smoothing model</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Adjusted exponential smoothing model</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Linear regression</td>
<td>✓</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Seasonal adjustments</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Multiple regression</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
</tbody>
</table>

(Continued)
<table>
<thead>
<tr>
<th>TOOLS AND TECHNIQUES</th>
<th>SOLVED EXAMPLES</th>
<th>HOMEWORK PROBLEMS</th>
<th>EXCEL EXAMPLES/PROBLEMS</th>
</tr>
</thead>
<tbody>
<tr>
<td>MAPE, MAD, MFE, and tracking signal</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td><strong>Chapter 10: Sales and Operations Planning (Aggregate Planning)</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Top-down sales and operations planning</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Bottom-up sales and operations planning</td>
<td>✓</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cash flow analysis</td>
<td>✓</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Load profiles</td>
<td>✓</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Optimization modeling (top-down sales and operations planning using Excel Solver function)</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td><strong>Chapter 11: Managing Inventory throughout the Supply Chain</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Periodic review systems</td>
<td>✓</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Economic order quantity</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Reorder points and safety stock</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Quantity discounts</td>
<td>✓</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Single-period inventory systems (newsboy problem)</td>
<td>✓</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pooling safety stock</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td><strong>Chapter 12: Managing Production across the Supply Chain</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Master scheduling</td>
<td>✓</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Material requirements planning (MRP)</td>
<td>✓</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Job sequencing rules</td>
<td>✓</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Distribution requirements planning (DRP)</td>
<td>✓</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Chapter 13: JIT/Lean Production</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Kanban sizing</td>
<td>✓</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Linking MRP and kanban</td>
<td>✓</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Chapter 14: Managing Projects</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gantt charts</td>
<td>✓</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Activity on node (AON) diagrams and critical path method (CPM)</td>
<td>✓</td>
<td>✓</td>
<td>Microsoft Project example</td>
</tr>
<tr>
<td>Project crashing</td>
<td>✓</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Chapter 15: Developing Products and Services</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Quality function deployment (QFD)</td>
<td>✓</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**MyLab Operations Management**

**Reach Every Student by Pairing This Text with MyLab Operations Management.** MyLab is the teaching and learning platform that empowers you to reach every student. By combining trusted author content with digital tools and a flexible platform, MyLab personalizes the learning experience and improves results for each student. Learn more about MyLab Operations Management at www.pearson.com/mylab/operations-management.

**Deliver Trusted Content.** You deserve teaching materials that meet your own high standards for your course. That’s why we partner with highly respected authors to develop interactive content and course-specific resources that you can trust—and that keep your students engaged.

**Empower Each Learner.** Each student learns at a different pace. Personalized learning pinpoints the precise areas where each student needs practice, giving all students the support they need—when and where they need it—to be successful.

**Teach Your Course Your Way.** Your course is unique. So whether you’d like to build your own assignments, teach multiple sections, or set prerequisites, MyLab gives you the flexibility to easily create your course to fit your needs.

**Improve Student Results.** When you teach with MyLab, student performance improves. That’s why instructors have chosen MyLab for more than 15 years, touching the lives of over 50 million students.
DEVELOPING EMPLOYABILITY SKILLS

This book covers many skills that hiring managers identify as important to success in a variety of business settings, including small and large firms, nonprofit organizations, and public service.

Critical Thinking

Critical thinking involves purposeful and goal-directed thinking used to define and solve problems, make decisions, or form judgments related to a particular situation or set of circumstances. This book is filled with dozens of useful frameworks that managers regularly use to support problem solving, including the Six Sigma methodology (Chapter 4), decision tree analysis (Chapter 6), sourcing portfolio analysis (Chapter 7), and project management tools (Chapter 14). It is not an exaggeration to say that critical thinking and fact-based decision making are built into the DNA of the operations and supply chain discipline.

Collaboration

Many key operations and supply chain activities require close collaboration with participants from other areas, such as marketing, engineering, and finance. Throughout this book, we will emphasize the importance of cross-functional collaboration as well as collaboration with outside supply chain partners. Forecasting (Chapter 9) and inventory management (Chapter 11) are just two areas in which collaboration is essential for the process to work. Chapter 10, in fact, is devoted to sales and operations planning, an approach to planning that depends entirely on collaboration and negotiation between operations, marketing, finance, and human resources in order to succeed.
Knowledge Application and Analysis

Knowledge application and analysis is defined as the ability to learn a concept and then apply that knowledge in another setting to achieve a higher level of understanding. Put another way, understanding is more than just memorizing formulas and cranking out answers. As such, this book seeks to move students “beyond the formulas” by illustrating how the concepts can be applied in a wide range of settings, using both extended examples and in-chapter case studies.

Information Technology Application and Computing Skills

Finally, information technology application and computing skills are defined as the ability to select and use appropriate technology to accomplish a given task. This book covers this skill set in a couple different ways. First, the book includes numerous, detailed examples of how Microsoft Excel can be used to carry out the various calculations covered in the text. Second, we have devoted the Chapter 12 supplement to understanding supply chain information system needs and reviewing recent trends in the area.

TABLE OF CONTENTS OVERVIEW

I. Creating Value through Operations and Supply Chains

| Ch. 1: Introduction to Operations and Supply Chain Management | Introduces basic concepts and definitions that lay the groundwork for future chapters |
| Ch. 2: Operations and Supply Chain Strategies | Discusses operations and supply chain strategies, including what they are, how they support the organization's overall strategy, and how they help a firm provide value to the customer |

II. Establishing the Operations Environment

| Ch. 3: Process Choice and Layout Decisions in Manufacturing and Services | Describes the manufacturing and service processes that firms put in place to provide products or services |
| Ch. 4: Business Processes | Introduces the topic of business processes, which can be thought of as the “molecules” that make up all operations and supply chain flows |
| Ch. 5: Managing Quality | Provides an overview of the different perspectives on quality, as well as some of the tools and techniques companies use to improve and monitor quality levels |
| Ch. 6: Managing Capacity | Discusses capacity and introduces several tools that managers use to evaluate capacity choices, including expected value analysis, waiting line theory, and Little’s Law |
III. Establishing Supply Chain Linkages

Ch. 7: Supply Management
Describes the broad set of activities carried out by organizations to analyze sourcing opportunities, develop sourcing strategies, select suppliers, and carry out all the activities required to procure goods and services.

Ch. 8: Logistics
Discusses the physical flow of goods throughout the supply chain and covers such areas as transportation, warehousing, and logistics decision models.

IV. Planning and Controlling Operations and Supply Chains

Ch. 9: Forecasting
Discusses the different types of forecasts firms use, and covers the most common quantitative forecasting methods.

Ch. 10: Sales and Operations Planning (Aggregate Planning)
Describes S&OP process and major approaches to developing plans. Additional topics include cash flow analysis and linking S&OP throughout the supply chain.

Ch. 11: Managing Inventory throughout the Supply Chain
Discusses the critical role of inventory, and tools and techniques for managing it.

Ch. 12: Managing Production across the Supply Chain
Introduces some of the systems manufacturers use to manage production and to coordinate these activities with their supply chain partners.

Ch. 13: JIT/Lean Production
Introduces the just-in-time (JIT)/Lean philosophy, and provides coverage of kanban production techniques.

V. Project Management and Product/Service Development

Ch. 14: Managing Projects
Describes how organizations manage projects, and covers common project management tools, including network-based models.

Ch. 15: Developing Products and Services
Addresses the product and service development process, with an emphasis on how these decisions directly affect choices in operations and supply chain management.

INSTRUCTOR TEACHING RESOURCES

This program comes with the following teaching resources.

<table>
<thead>
<tr>
<th>SUPPLEMENTS AVAILABLE TO INSTRUCTORS AT <a href="http://WWW.PEARSONHIGHERED.COM/BOZARTH">WWW.PEARSONHIGHERED.COM/BOZARTH</a></th>
<th>FEATURES OF THE SUPPLEMENT</th>
</tr>
</thead>
</table>
| Instructor’s Solutions Manual, authored by Geoff Willis from UCO College of Business | • Detailed solutions for all end-of-chapter Discussion Questions, Problems, and Case Study questions  
• Solutions of the Excel problems available on the Data Download page |
| Test Bank, authored by Geoff Willis from UCO College of Business | More than 1,500 multiple-choice, true/false, short-answer, and graphing questions with these annotations:  
• Difficulty level (1 for straight recall, 2 for some analysis, 3 for complex analysis)  
• Type (Multiple-choice, true/false, short-answer, essay)  
• Keywords (The term or concept the question supports)  
• Learning outcome  
• AACSB learning standard (Written and Oral Communication; Ethical Understanding and Reasoning; Analytical Thinking; Information Technology; Interpersonal Relations and Teamwork; Diverse and Multicultural Work; Reflective Thinking; Application of Knowledge) |

(Continued)
SUPPLEMENTS AVAILABLE TO INSTRUCTORS AT WWW.PEARSONHIGHERED.COM/BOZARTH

FEATURES OF THE SUPPLEMENT

Computerized TestGen
TestGen allows instructors to:
- Customize, save, and generate classroom tests
- Edit, add, or delete questions from the Test Item Files
- Analyze test results
- Organize a database of tests and student results

PowerPoints, authored by Dr. Kathryn A. Marley from Duquesne University
Slides include key Excel figures, graphs, tables, and equations in the textbook
PowerPoints meet accessibility standards for students with disabilities.
Features include, but not limited to:
- Keyboard and Screen Reader access
- Alternative text for images
- High color contrast between background and foreground colors

Excel Problems
Instructors can create different homework problems for different class sections and even different students. This feature is ideal for instructors teaching large sections of an introductory operations/supply chain course. With these homework problems, professors have an extra measure to guard against plagiarism in homework assignments. Here’s how it works:

1. Students go to the Multimedia Library in MyLab Operations Management or to the Data Download page at www.pearsonhighered.com/bozarth and open an Excel spreadsheet listed under the chapter of interest.
2. Students type their name and a four-digit number chosen by the instructor into the spreadsheet. The four-digit number creates new parameters for the problem.
3. Students print out their customized homework sets and solve the problems.
4. The instructor uses an Excel-based key that uses the same four-digit number to generate the correct answers.

If assistance is needed, our dedicated technical support team is ready to help with the media supplements that accompany this text. Visit support.pearson.com/getsupport for answers to frequently asked questions and toll-free user support phone numbers.

ACKNOWLEDGMENTS

We would like to thank the following reviewers of the previous editions:

R. C. Baker, University of Texas at Arlington
David L. Bakuli, Westfield State College
Gregory L. Bier, University of Missouri
Terrence M. Boardman, East Carolina University
Kimball Bullington, Middle Tennessee State University
David T. Cadden, Quinnipiac University
Cem Canel, University of North Carolina at Wilmington
Sohail Chaudhry, Villanova University
Christopher W. Craighead, University of North Carolina at Charlotte
Richard E. Crandall, Appalachian State University
Barry A. Cumbie, University of Southern Mississippi
Sime Curkovic, Western Michigan University
Eduardo C. Davila, Arizona State University
Kenneth H. Doerr, University of Miami
Matthew J. Drake, Duquesne University
Ike C. Ehie, Kansas State University
Lawrence P. Ettkin, University of Tennessee at Chattanooga
Jared Everett, Boise State University
Kamvar Farahbod, California State University, San Bernardino
Donavon Favre, North Carolina State University
Geraldo Ferrar, University of North Carolina at Chapel Hill
Bruce G. Ferrin, Western Michigan University
Gene Fliedner, Oakland University
Tom Foster, Brigham Young University
Ram Ganeshan, University of Cincinnati
Janet L. Hartley, Bowling Green State University
Ray M. Haynes, California Polytechnic State University, San Luis Obispo
Lesley Gail Scamacca Holmer, The Pennsylvania State University
Seung-Lae Kim, Drexel University
Timothy J. Kloppenborg, Xavier University
Terry Nels Lee, Brigham Young University
Binshan Lin, Louisiana State University in Shreveport
Rhonda R. Lummus, Iowa State University
Daniel S. Marrone, State University of New York Farmingdale
Mark McKay, University of Washington
Mohammad Meybodi, Indiana University Kokomo
Philip F. Musa, Texas Tech University
Joao S. Neves, The College of New Jersey
Barbara Osky, The University of Akron
Fariborz Y. Partovi, Drexel University
Charles Petersen, Northern Illinois University
Carl J. Poch, Northern Illinois University
Robert F. Reck, Western Michigan University
Richard A. Reid, University of New Mexico
Shane J. Schvaneveldt, Weber State University
V. Sridharan, Clemson University
Mahesh Srinivasan, The University of Akron
Harm-Jan Steenhuis, Eastern Washington University
Joaquin Tadeo, University of Texas at El Paso
V. M. Rao Tummala, Eastern Michigan University
Elisabeth Umble, Baylor University
Enrique R. Venta, Loyola University Chicago
Y. Helio Yang, San Diego State University