# Contents

1 Introduction to Integrated Systems Approach to Materials Management ........................................... 1
  1.1 Importance of Materials Management ........................................ 2
  1.2 Efficiency Indicators of Materials Management ............................. 2
  1.3 Definition of Materials Management ........................................ 3
  1.4 Some Indicators of Low Materials Management Effectiveness .......... 3
  1.5 Materials Management in India: Some Reflections/Concerns ............ 4
  1.6 Major Reasons of Low Materials Productivity ............................. 5
    1.6.1 Lack of Integrated Approach in Dealing with the Materials .......... 5
    1.6.2 Hidden Costs Associated with Managing Materials ................ 6
    1.6.3 Lack of Use of Scientific Methods of Planning and Control in Materials Management Function .... 7
    1.6.4 Uncertainty of Demand and Supply in the Supply Environment ........ 7
    1.6.5 Low Organizational Importance to Materials Management in the Organizational Structure .......... 7
    1.6.6 Terminological Confusion ........................................... 8
    1.6.7 Inflationary Pressures ............................................. 8
  1.7 Integrated Systems Approach to Materials Management: An Overview ........................................... 8
    1.7.1 Inventory Management ............................................... 10
    1.7.2 Materials Handling and Transportation ................................ 10
    1.7.3 Storage and Warehousing .......................................... 11
    1.7.4 Waste Management (or SOS Management) ............................ 11
    1.7.5 Make or Buy Decisions or Outsourcing ............................... 12
    1.7.6 Incoming Materials Quality Assurance ............................... 12
    1.7.7 Vendor Selection, Evaluation, and Development ..................... 12
    1.7.8 Value Analysis for Cost Avoidance or Reduction ..................... 13
    1.7.9 Lead Time Analysis, Value Stream Mapping, and Process Simplification ...... 13
    1.7.10 Standardization, Codification, and Variety Reduction ............... 14
1.7.11 IT-Enabled Systems ........................................ 14
1.7.12 Supply Chain Management: System Integration ...... 15
1.7.13 Purchasing Systems for Ensuring Right Price ........ 15
1.7.14 Organization Structure for Effective
       Materials Management .................................. 15
1.7.15 Materials Management Audit, Performance
       Monitoring, and Evaluation ............................ 16

1.8 Overview of the Book .................................. 16
1.9 Summary of the Chapter ................................ 17
1.10 Review Questions .................................... 17
1.11 Case Study ........................................... 18
   1.11.1 A Trauma in the Trauma Center .................. 18

2 Basic Concepts in Inventory Management .................. 21
2.1 What Is Inventory? ................................... 21
2.2 Types of Inventories .................................. 22
2.3 Why Do We Need Inventories? ........................ 22
2.4 Just-in-Time or Zero-Inventory Essentials ............... 23
2.5 Functions of Inventory: A Mechanical Analogy .......... 24
2.6 What Is an Inventory Problem? ........................ 25
2.7 Estimation of Inventory-Related Cost Parameters ....... 26
2.8 Inventory Models ..................................... 28
2.9 Inventory Policies .................................... 29
2.10 Taxonomy of Inventory Models ........................ 32
2.11 Summary and Concluding Remarks ..................... 33
2.12 Conceptual Questions ................................ 34
2.13 Case Study .......................................... 34
References .............................................. 36

3 Selective Inventory Management ............................ 37
3.1 Need for Selective Inventory Management ............... 37
3.2 Pareto’s Law of Maldistribution ........................ 38
3.3 ABC Analysis ......................................... 40
3.4 VED Analysis ......................................... 43
3.5 ABC-VED Matrix and Service Levels .................... 43
3.6 FSN Analysis ......................................... 44
3.7 GOLF Analysis ....................................... 45
3.8 Strategies to Select Appropriate Inventory Models
       with SIM ............................................. 46
3.9 Summary of the Chapter ................................ 46
3.10 Review Questions .................................... 46
3.11 Case Study .......................................... 47
Reference .............................................. 49
<table>
<thead>
<tr>
<th>Section</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>6.3</td>
<td>Sensitivity Analysis of EOQ Model</td>
</tr>
<tr>
<td>6.3.1</td>
<td>Illustrations of Sensitivity Analysis of EOQ Model</td>
</tr>
<tr>
<td>6.4</td>
<td>Variants of Classical EOQ Model</td>
</tr>
<tr>
<td>6.4.1</td>
<td>Inventory Model with Planned Backlogging</td>
</tr>
<tr>
<td>6.4.2</td>
<td>Inventory Model with Finite Replenishment Rate</td>
</tr>
<tr>
<td>6.4.3</td>
<td>Zero-Inventory System: The Just-in-Time (JIT) System</td>
</tr>
<tr>
<td>6.4.4</td>
<td>A Generalized Inventory Model</td>
</tr>
<tr>
<td>6.4.5</td>
<td>Inventory Model with Lost Sales</td>
</tr>
<tr>
<td>6.4.6</td>
<td>Inventory Models with “Stock-Dependent” Consumption Rate</td>
</tr>
<tr>
<td>6.5</td>
<td>Multi-item Inventory Models</td>
</tr>
<tr>
<td>6.5.1</td>
<td>Multi-item Inventory Model with Budget Constraint</td>
</tr>
<tr>
<td>6.5.2</td>
<td>Multi-item Single Source Model: Coordinated Replenishment</td>
</tr>
<tr>
<td>6.6</td>
<td>Periodic Review Inventory Models</td>
</tr>
<tr>
<td>6.7</td>
<td>Multi-item Periodic Review Inventory Model with Limited Shortages</td>
</tr>
<tr>
<td>6.8</td>
<td>Reorder Point in Deterministic EOQ Model</td>
</tr>
<tr>
<td>6.9</td>
<td>Summary of the Chapter</td>
</tr>
<tr>
<td>6.10</td>
<td>Conceptual/Review Questions</td>
</tr>
<tr>
<td>6.11</td>
<td>Numerical Questions</td>
</tr>
<tr>
<td>6.12</td>
<td>Case Study</td>
</tr>
<tr>
<td>References</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>Dynamic Inventory Models with Quantity Discounts</td>
</tr>
<tr>
<td>7.1</td>
<td>Concept of Quantity Discounts</td>
</tr>
<tr>
<td>7.2</td>
<td>Types of Quantity Discounts</td>
</tr>
<tr>
<td>7.3</td>
<td>Inventory Models with All-Unit Discounts</td>
</tr>
<tr>
<td>7.3.1</td>
<td>Generalized Solution Methodology: All-Unit Discounts</td>
</tr>
<tr>
<td>7.3.2</td>
<td>Illustrative Example with Single Price Break</td>
</tr>
<tr>
<td>7.3.3</td>
<td>Illustrative Example with Two Price Breaks</td>
</tr>
<tr>
<td>7.4</td>
<td>Inventory Models with Incremental Discounts</td>
</tr>
<tr>
<td>7.4.1</td>
<td>Illustrative Example for Incremental Discounts</td>
</tr>
<tr>
<td>7.5</td>
<td>Other Inventory Situations Which Impact on Purchase Costs</td>
</tr>
<tr>
<td>7.5.1</td>
<td>Inventory Models with General Inflationary Trend</td>
</tr>
<tr>
<td>7.5.2</td>
<td>Purchase Quantity in Response to Price Increase Announced at a Given Date in the Future</td>
</tr>
<tr>
<td>7.5.3</td>
<td>Ethical Issues in Overstocking in Anticipation of Price Increase</td>
</tr>
<tr>
<td>7.6</td>
<td>Summary of the Chapter</td>
</tr>
<tr>
<td>7.7</td>
<td>Conceptual/Review Questions</td>
</tr>
<tr>
<td>7.8</td>
<td>Numerical Questions</td>
</tr>
<tr>
<td>7.9</td>
<td>Case Study</td>
</tr>
<tr>
<td>References</td>
<td></td>
</tr>
</tbody>
</table>
### 8 Probabilistic Inventory Models

<table>
<thead>
<tr>
<th>Section</th>
<th>Title</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>8.1</td>
<td>Relevance of Probabilistic Inventory Models</td>
<td>123</td>
</tr>
<tr>
<td>8.2</td>
<td>Estimation of Demand and Lead Time Variability</td>
<td>123</td>
</tr>
<tr>
<td>8.2.1</td>
<td>Demand Variability</td>
<td>124</td>
</tr>
<tr>
<td>8.2.2</td>
<td>Lead Time Variability</td>
<td>127</td>
</tr>
<tr>
<td>8.3</td>
<td>Probabilistic Inventory Model for Continuous Review Inventory Policy</td>
<td>127</td>
</tr>
<tr>
<td>8.4</td>
<td>Safety Stock Determination</td>
<td>130</td>
</tr>
<tr>
<td>8.4.1</td>
<td>Avoid 99% Syndrome</td>
<td>131</td>
</tr>
<tr>
<td>8.4.2</td>
<td>Special Cases</td>
<td>131</td>
</tr>
<tr>
<td>8.5</td>
<td>Deterministic of EOQ-ROP in Probabilistic Model</td>
<td>132</td>
</tr>
<tr>
<td>8.6</td>
<td>A Generalized Approach to Determine Reorder Point</td>
<td>133</td>
</tr>
<tr>
<td>8.7</td>
<td>Exchange Curve Concept for Safety Stock at Aggregate Level</td>
<td>134</td>
</tr>
<tr>
<td>8.8</td>
<td>Need for Proactive Approach to Reduce Variability</td>
<td>135</td>
</tr>
<tr>
<td>8.9</td>
<td>Probabilistic Inventory Models for Periodic Review Policy</td>
<td>135</td>
</tr>
<tr>
<td>8.9.1</td>
<td>The Probabilistic Order-Level System</td>
<td>137</td>
</tr>
<tr>
<td>8.10</td>
<td>The ((s, S, T)) Policy or Optional Replenishment Policy</td>
<td>139</td>
</tr>
<tr>
<td>8.11</td>
<td>Simulation of Inventory Systems</td>
<td>140</td>
</tr>
<tr>
<td>8.12</td>
<td>Summary of the Chapter and Concluding Remarks</td>
<td>145</td>
</tr>
<tr>
<td>8.13</td>
<td>Conceptual/Review Questions</td>
<td>146</td>
</tr>
<tr>
<td>8.14</td>
<td>Numerical Problem</td>
<td>147</td>
</tr>
<tr>
<td>8.15</td>
<td>Case Study</td>
<td>148</td>
</tr>
</tbody>
</table>

References | 150 |

### 9 Just-in-Time, MRP, and Lean Supply Chains

<table>
<thead>
<tr>
<th>Section</th>
<th>Title</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>9.1</td>
<td>Materials Planning Under JIT Environment</td>
<td>151</td>
</tr>
<tr>
<td>9.2</td>
<td>A Perfect Example of JIT (Zero-Inventory) System</td>
<td>151</td>
</tr>
<tr>
<td>9.3</td>
<td>Key Requirements for Successful JIT System</td>
<td>152</td>
</tr>
<tr>
<td>9.4</td>
<td>Pull- vs. Push-Based Inventory Planning</td>
<td>153</td>
</tr>
<tr>
<td>9.5</td>
<td>Materials Requirement Planning (MRP) Under Dependent Demand</td>
<td>156</td>
</tr>
<tr>
<td>9.5.1</td>
<td>MRP Concept and Flow Chart</td>
<td>157</td>
</tr>
<tr>
<td>9.5.2</td>
<td>An Illustrative Example of MRP</td>
<td>158</td>
</tr>
<tr>
<td>9.5.3</td>
<td>Limitations of MRP and Further Refinements</td>
<td>158</td>
</tr>
<tr>
<td>9.5.4</td>
<td>Lot Sizing Algorithms in MRP</td>
<td>160</td>
</tr>
<tr>
<td>9.6</td>
<td>Concept of Lean Supply Chain</td>
<td>166</td>
</tr>
<tr>
<td>9.7</td>
<td>Strategies for Inventory Reduction in Lean Supply Chain</td>
<td>166</td>
</tr>
<tr>
<td>9.7.1</td>
<td>Reducing Variability of Demand and Lead Time</td>
<td>166</td>
</tr>
<tr>
<td>9.7.2</td>
<td>Avoid More Service Level Than Desired</td>
<td>167</td>
</tr>
<tr>
<td>9.7.3</td>
<td>Simplify Procurement Processes to Reduce Average Lead Time</td>
<td>167</td>
</tr>
<tr>
<td>9.7.4</td>
<td>Reduce Excessive Variety Through Simplification/Standardization</td>
<td>167</td>
</tr>
</tbody>
</table>

References | 150 |
9.7.5 Vendor Development and VMI .......................... 168
9.7.6 Lean Purchasing and Logistics ......................... 168
9.7.7 Centralization of Expensive Slow-Moving
Inventory and Risk Pooling .................................. 168
9.8 Chapter Summary and Concluding Remarks ............... 168
9.9 Conceptual/Review Questions ............................. 169
9.10 Numerical Questions ..................................... 170
9.11 Case Study ................................................. 171
References .......................................................... 173

10 Inventory Management of Slow-Moving Materials .......... 175
10.1 Concept of Slow-Moving Materials .......................... 175
10.2 Why Conventional Approach Does Not Work
for Slow-Moving Items? ........................................ 176
10.3 Classification of Slow-Moving Spares ....................... 177
10.3.1 Strategy for “Special” Spares .......................... 177
10.3.2 Adequate Warning Spares ............................. 179
10.3.3 Inadequate Warning Spares ........................... 179
10.3.4 An Illustrative Example ............................... 181
10.3.5 Risk Pooling of Slow-Moving Spares ................ 181
10.3.6 (S - 1, S) Inventory Policy
for Slow-Moving Spares ...................................... 183
10.4 Inventory Management of Rotable Spares .................. 183
10.4.1 Importance of the Rotable Inventory .................. 183
10.4.2 Models for Optimal Number of Rotable Spares .... 184
10.4.3 Trade-offs Between Rotable Inventory
and Maintenance Capacity ................................. 186
10.5 Summary of the Chapter/Concluding Remarks ............ 187
10.6 Conceptual/Review Questions ............................. 188
10.7 Numerical Problems ...................................... 189
10.8 Case Study ................................................. 191
References .......................................................... 193

11 Multi-echelon Inventory Models .............................. 195
11.1 Introduction to Multi-echelon Inventory Systems .......... 195
11.2 Structure of Multi-echelon Inventory Systems ............ 196
11.3 Need for a Multi-echelon Inventory System: Concept
of Supply Chain ................................................ 196
11.4 Strategic, Tactical, and Operational Issues Involved .... 199
11.5 A Simple Multi-echelon Inventory System:
The Base Stock Control System ............................. 201
11.6 Multi-echelon Repair: Inventory System .................. 202
11.7 Chapter Summary/Concluding Remarks .................... 205
11.8 Conceptual/Review Questions ............................. 205
11.9 Numerical Problems ...................................... 206
11.10 Case Study ................................................. 208
References .......................................................... 210
14.4 Stores Location and Layout Planning .................................................. 246
   14.4.1 Stores Location Models ......................................................... 246
   14.4.2 Stores Layout Planning ......................................................... 248
14.5 Store Address System: Location Code for Materials .............................. 248
14.6 Design of Storage Systems and Selection of Storage Equipment ................. 250
14.7 Storage Methods ............................................................................ 251
14.8 Units of Issue: Item Control vs. Bulk Control .................................... 252
14.9 Guiding Principles in Efficient Stores Management .................................. 253
14.10 Automated Storage and Retrieval (AS/R) Systems ............................ 253
14.11 Physical Stock Verification: The Need, Process, and Control Measures ......... 254
   14.11.1 Discrepancy Report Preparation ............................................... 255
   14.11.2 Control Chart or Tolerance-Band Approach for Follow-Up .............. 256
14.12 Stock Accounting Methods ............................................................. 256
14.13 Summary of the Chapter .................................................................. 258
14.14 Review/Conceptual Questions .......................................................... 259
14.15 Numerical Questions ........................................................................ 260
14.16 Case Study ..................................................................................... 261
15 Purchasing: Policies and Processes ......................................................... 263
   15.1 Role of Efficient Purchasing in Materials Management ......................... 263
   15.2 Strategies to Ensure the “Right” Price for Materials ............................ 264
   15.3 Published Price and MRP (Maximum Retail Price) ............................. 265
   15.4 Purchase Price Analysis ................................................................... 265
   15.5 Competitive Bidding for Obtaining the Right Price ......................... 266
   15.6 Negotiations to Ensure the Right Price ............................................. 269
      15.6.1 When to Negotiate ................................................................. 269
      15.6.2 The Negotiation Process ......................................................... 270
      15.6.3 Dynamics of Negotiating Behavior ......................................... 271
      15.6.4 Some Techniques of Negotiation ........................................... 272
   15.7 The Purchasing Chessboard™ .......................................................... 273
   15.8 Lead Time Reduction: Improvement in Systems and Procedures ........... 275
   15.9 e-Tendering/e-Procurement: The Game Changers in Purchasing .......... 277
   15.10 Organization of Purchasing Function ............................................ 278
      15.10.1 Centralization vs. Decentralization of Purchasing ..................... 278
   15.11 Summary of the Chapter .................................................................. 280
   15.12 Review/Conceptual Questions .......................................................... 281
   15.13 Numerical Questions ...................................................................... 282
   15.14 Case Study .................................................................................... 283
References ............................................................................................... 285
16 Incoming Materials Quality Assurance ........................................ 287
  16.1 Role of Quality Assurance for Incoming Materials ................. 287
  16.2 Objectives of Inspection in Quality Assurance ..................... 288
  16.3 Economics of Inspection .............................................. 289
  16.4 Theory of Sampling Inspection and Types
      of Sampling Plans .................................................. 291
  16.5 Single Sampling Plans ............................................... 292
      16.5.1 The Operating Characteristics Curve ......................... 292
      16.5.2 Acceptance-Rectification Sampling Plans .................... 294
  16.6 Double Sampling Acceptance Plans ................................. 295
  16.7 Optimal Design/Selection of Inspection Policy ................... 297
  16.8 Summary of the Chapter ............................................. 298
  16.9 Review/Conceptual Questions ...................................... 299
  16.10 Numerical Problems .................................................. 300
  16.11 Case Study .......................................................... 300

17 Make or Buy Decisions: Outsourcing Strategy ............................ 303
  17.1 Need for Make or Buy Decisions ................................... 304
  17.2 Situational Contexts of Make or Buy Decisions ................... 304
  17.3 Incremental Cost Concept for Make or Buy ........................ 305
  17.4 Factors in Favor of Making .......................................... 306
  17.5 Factors in Favor of Buying .......................................... 307
  17.6 Strategic Nature of Make or Buy Decisions ......................... 308
  17.7 Multi-criteria Evaluation of Make or Buy Decisions .............. 311
  17.8 Dynamic Nature of Make or Buy Decisions ........................ 312
  17.9 Summary of the Chapter ............................................. 312
  17.10 Review/Conceptual Questions .................................... 313
  17.11 Numerical Questions ............................................... 313
  17.12 Case Study .......................................................... 315
  References ............................................................. 316

18 Source Selection, Performance Rating, and Development .............. 317
  18.1 Strategic Importance of Source of Supply (Vendor) ............... 318
  18.2 Attributes of a Good Vendor ........................................ 318
  18.3 Process of Searching/Selecting an Appropriate Vendor ............ 319
  18.4 Multi-criteria Decision Models for Vendor Selection ............ 321
  18.5 Source Selection in a Fuzzy Environment .......................... 322
  18.6 Vendor Rating: An Important Tool in Vendor Management ....... 323
      18.6.1 Some Commonly Used Vendor Rating Plans .................... 324
  18.7 AHP and Other Multi-criteria Evaluation
      of Vendor Performance ............................................. 326
      18.7.1 AHP Application to Vendor Rating ............................ 326
  18.8 Use of Vendor Rating Data for Vendor
      Relationship Management ............................................ 329
      18.8.1 Vendor Certification Plan .................................... 329
18.9 Vendor Development: Concept, Importance, and Strategies ........................................... 330
18.10 Some Other Policy Issues Concerning Vendors .................. 330
18.11 Summary of the Chapter ................................................. 332
18.12 Review/Conceptual Questions ........................................... 333
18.13 Numerical Problems ....................................................... 334
18.14 Case Study ............................................................... 335
References ............................................................... 337

19 Value Analysis for Material Cost Reduction ......................... 339
19.1 Origin of Value Analysis .................................................. 340
19.2 Identification of Low Value Areas .................................... 341
19.3 The Value Engineering Job Plan ........................................ 342
19.4 Important Techniques of Value Engineering ....................... 343
19.5 Role of Creativity in Value Engineering .............................. 347
19.6 Cost Avoidance vs. Cost Reduction in Value Analysis .......... 350
19.7 Organizational Aspects in Value Engineering ....................... 351
19.8 Examples of Cost Reduction Through Value Analysis .......... 352
19.9 Summary of the Chapter/Concluding Remarks .................... 353
19.10 Review Questions ......................................................... 354
19.11 Case Study ............................................................... 354
References ............................................................... 356

20 Systems Approach and Supply Chain Management .................. 357
20.1 Commonality Between Systems Approach and Supply Chain Management ........................................... 358
20.2 Supply Chain Management: Concepts, Structure, and Overview ....................................................... 358
20.2.1 Importance of SCM and Enablers .................................. 360
20.2.2 Supply Chain Performance in India ............................... 360
20.2.3 Types of Supply Chains ................................................ 361
20.2.4 Improving Supply Chain Performance ......................... 361
20.3 Analysis of Material Flow Through Supply Chain .................. 363
20.3.1 Modes of Transportation ............................................. 363
20.4 Managing Information Flow in Supply Chains ...................... 364
20.4.1 Bullwhip Effect in Supply Chains ................................. 366
20.5 Supply Chain Integration Strategies .................................... 367
20.6 Supply Chain Restructuring .............................................. 367
20.6.1 Postponement Strategy .............................................. 368
20.6.2 Advancement of Customer Ordering Point ...................... 368
20.6.3 Change in the Shape of Value-Addition Curve ................. 369
20.7 Restructuring of Supply Chain Architecture ......................... 370
20.8 Agile Supply Chains ....................................................... 370
20.9 Reverse/Green Supply Chains ........................................... 371
Materials Management
An Integrated Systems Approach
Vrat, P.
2014, XXIII, 408 p. 125 illus., Hardcover