

BUSINESS LOGISTICS/ SUPPLY CHAIN MANAGEMENT

F I F T H E D I T I O N



RONALD H. BALLOU

Business Logistics/ Supply Chain Management

Planning, Organizing, and
Controlling the Supply Chain

F I F T H E D I T I O N

Ronald H. Ballou

*Weatherhead School of Management
Case Western Reserve University*



Upper Saddle River, New Jersey 07458

Library of Congress Cataloging-in-Publication Data

Ballou, Ronald H.

Business logistics/supply chain management: planning, organizing, and controlling the supply chain / Ronald H. Ballou.--5th ed.

p. cm.

Rev. ed. of: Business logistics management, 4th ed. ©1999.

Includes bibliographical references and index.

ISBN 0-13-066184-8 (case)

1. Business logistics. I. Ballou, Ronald H.--Business logistics management.

II. Title

HD38.5.B35 2004

658.7'8--dc21

2003054845

Acquisitions Editor: Wendy Craven

Editor-in-Chief: Jeff Shelstad

Assistant Editor: Melissa Pellerano

Editorial Assistant: Danielle Serra

Media Project Manager: Anthony Palmiotto

Marketing Manager: Michelle O'Brien

Marketing Assistant: Amanda Fisher

Managing Editor (Production): John Roberts

Production Editor: Maureen Wilson

Permissions Supervisor: Suzanne Grappi

Manufacturing Buyer: Michelle Klein

Cover Design: Lisa Boylan

Cover Illustration/Photo: Felix Clouzot/Getty Images Inc.—Image Bank

Composition/Full-Service Project Management: Progressive Publishing Alternatives

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

Copyright © 2004, 1999, 1992 by Pearson Education, Inc., Upper Saddle River, New Jersey, 07458.

Pearson Prentice Hall. All rights reserved. Printed 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. For information regarding permission(s), write to: Rights and Permissions Department.

Pearson Prentice Hall™ is a trademark of Pearson Education, Inc.

Pearson® is a registered trademark of Pearson plc

Prentice Hall® is a registered trademark of Pearson Education, Inc.

Pearson Education LTD.

Pearson Education Singapore, Pte. Ltd

Pearson Education, Canada, Ltd

Pearson Education—Japan

Pearson Education Australia PTY, Limited

Pearson Education North Asia Ltd

Pearson Educación de México, S.A. de C.V.

Pearson Education Malaysia, Pte. Ltd



10 9 8 7
ISBN 0-13-066184-8

***Business Logistics/
Supply Chain Management***

For logistics/supply chain managers everywhere:

I have heard of you . . . that light and understanding and excellent wisdom are found in you . . . I have heard that you give interpretations and solve problems . . . you shall be clothed with purple and have a chain of gold about your neck.

—DANIEL 5:14

PREFACE

No book that will not improve by repeated readings deserves to be read at all.

—THOMAS CARLYLE

This book is about the vital subject of business logistics/supply chain—an area of management that has been observed to absorb as much as 60 to 80 percent of a firm's sales dollar and that can be essential to a firm's competitive strategy and revenue generation. This management area has been described by many names, including physical distribution, materials management, transportation management, logistics, and now supply chain management. The business activities of concern may include all or part of the following: transportation, inventory maintenance, order processing, purchasing, warehousing, materials handling, packaging, customer service standards, and production.

The focus of this book is on the planning, organizing, and controlling of these activities—key elements for successful management in any organization. Special emphasis is given to strategic planning and decision making as perhaps the most important parts of the management process. The mission of this managerial effort is to set the level of the logistics activities so as to make products and services available to customers at the time, place, and in the condition and form desired, in the most profitable or cost-effective way.

Because logistics activities have always been vital to companies and organizations, the field of business logistics/supply chain management represents a synthesis of many concepts, principles, and methods from the more traditional areas of marketing, production, accounting, purchasing, and transportation, as well as from the disciplines of applied mathematics, organizational behavior, and economics. This book attempts to unify these into a logical body of thought that can lead to the effective management of the supply chain.

As with any field of management, there are frequently changing terms to capture the methods and concepts of business logistics/supply chain. An attempt has been made to resist following the popular press and fads, and to present the ideas, principles, and techniques that are fundamental to good business logistics practice, now and in the near future. In this spirit, the fifth edition is organized around two themes. First, the basic activities of management, namely, planning, organizing, and controlling, provide the overarching theme for the book. Second, a triangle of interrelated transportation, inventory, and location strategies are at the heart of good logistics planning and decision making. This triangle is emphasized through the text.

Several trends have been noted that affect the scope and practice of business logistics/supply chain. These have been integrated into the body of the text as application illustrations of the fundamental ideas being presented. First, emphasis is placed on logistics/supply chain in a worldwide setting to reflect the growing internationalization and globalization of business in general. Second, the shifting toward more service-oriented economies by industrialized nations is emphasized by showing how logistics concepts and principles are equally applicable to service-producing firms as they are to product-producing ones. Third, attention is given to the integrated management of supply chain activities, as well as managing these activities among the other functional areas of business as well as across multiple enterprises. Fourth, many practical examples are given to show the applicability of the material. Fifth, computer software is provided to assist in solving logistics/supply chain problems reflecting the growing use of computer technology in managerial decision making.

Over the years, so many people and companies have contributed to the ideas embodied in this fifth edition that a list of acknowledgments would be far too long to print. However, to all those students and professors around the world who were willing to comment on the previous editions, to those businesspeople who were willing to try the ideas embodied in them, and to all others who made comments of praise as well as criticism—my heartfelt thanks. A special note of gratitude goes to my wife, Carolyn, for editorial assistance and encouragement throughout this revision. Considering all of this help, any shortcomings and errors that remain must be mine.

R. H. BALLOU
Weatherhead School of Management
Cleveland, Ohio

*Business Logistics/
Supply Chain Management*

BRIEF CONTENTS

PREFACE xxi

PART I: INTRODUCTION AND PLANNING 1

Chapter 1 Business Logistics/Supply Chain—A Vital Subject 1

Chapter 2 Logistics/Supply Chain Strategy and Planning 33

PART II: CUSTOMER SERVICE GOALS 62

Chapter 3 The Logistics/Supply Chain Product 62

Chapter 4 Logistics/Supply Chain Customer Service 91

Chapter 5 Order Processing and Information Systems 130

PART III: TRANSPORT STRATEGY 164

Chapter 6 Transport Fundamentals 164

Chapter 7 Transport Decisions 219

PART IV: INVENTORY STRATEGY 286

Chapter 8 Forecasting Supply Chain Requirements 286

Chapter 9 Inventory Policy Decisions 326

Chapter 10 Purchasing and Supply Scheduling Decisions 424

Chapter 11 The Storage and Handling System 469

Chapter 12 Storage and Handling Decisions 501

PART V: LOCATION STRATEGY 550

Chapter 13 Facility Location Decisions 550

Chapter 14 The Network Planning Process 618

PART VI: ORGANIZATION AND CONTROL 691

Chapter 15 Logistics/Supply Chain Organization 691

Chapter 16 Logistics/Supply Chain Control 726

CONTENTS

PREFACE xxi

PART I: INTRODUCTION AND PLANNING 1

CHAPTER 1 Business Logistics/Supply Chain—A Vital Subject 1

Introduction	1
Business Logistics Defined	3
The Supply Chain	7
The Activity Mix	9
Importance of Logistics/Supply Chain	13
<i>Costs Are Significant</i>	13
<i>Logistics Customer Service Expectations Are Increasing</i>	14
<i>Supply and Distribution Lines Are Lengthening with Greater Complexity</i>	15
<i>Logistics/SC Is Important to Strategy</i>	17
<i>Logistics/SC Adds Significant Customer Value</i>	18
<i>Customers Increasingly Want Quick, Customized Response</i>	19
<i>Logistics/SC in Nonmanufacturing Areas</i>	20
<i>Service Industry</i>	21
<i>Military</i>	22
<i>Environment</i>	23
Business Logistics/SC in the Firm	24
Objectives of Business Logistics/SC	27
Approach to the Study of Logistics/SC	28
Questions and Problems	30
<i>Examples of Good Logistics/Supply Chain Strategy, or Lack Thereof</i>	32

CHAPTER 2 Logistics/Supply Chain Strategy and Planning 33

Corporate Strategy	34
Logistics/SC Strategy	35
Logistics/SC Planning	38
<i>Levels of Planning</i>	38
<i>Major Planning Areas</i>	39
<i>Conceptualizing the Logistics/SC Planning Problem</i>	41
<i>When to Plan</i>	42
<i>Guidelines for Strategy Formulation</i>	44

Selecting the Proper Channel Strategy	53
Measuring Strategy Performance	57
<i>Cash Flow</i>	57
<i>Savings</i>	57
<i>Return on Investment</i>	57
Concluding Comments	58
Questions	58

PART II: CUSTOMER SERVICE GOALS 62

CHAPTER 3 The Logistics/Supply Chain Product 62

Nature of the Logistics/SC Product	63
<i>Classifying Products</i>	63
<i>The Product Life Cycle</i>	65
The 80-20 Curve	68
Product Characteristics	72
<i>Weight-Bulk Ratio</i>	72
<i>Value-Weight Ratio</i>	73
<i>Substitutability</i>	74
<i>Risk Characteristics</i>	74
Product Packaging	76
Product Pricing	77
<i>Geographic Pricing Methods</i>	77
Some Legal Concerns	84
Incentive Pricing Arrangements	84
<i>Quantity Discounts</i>	84
<i>The Deal</i>	86
Concluding Comments	86
Questions	87

CHAPTER 4 Logistics/Supply Chain Customer Service 91

Customer Service Defined	92
<i>Customer Service Elements</i>	93
<i>Relative Importance of Service Elements</i>	94
Order Cycle Time	98
<i>Adjustments to Order Cycle Time</i>	101
Importance of Logistics/SC Customer Service	102
<i>Service Effects on Sales</i>	102
<i>Service Effects on Customer Patronage</i>	104
Defining a Sales-Service Relationship	105

Modeling the Sales-Service Relationship	107
<i>Two-Points Method</i>	107
<i>Before-After Experiments</i>	108
<i>Game Playing</i>	108
<i>Buyer Surveys</i>	109
Cost versus Service	109
Determining Optimum Service Levels	110
<i>Theory</i>	110
<i>Practice</i>	111
Service Variability	114
<i>Loss Function</i>	114
<i>Information Substitution</i>	116
Service as a Constraint	117
Measuring Service	118
Service Contingencies	119
<i>System Breakdown</i>	119
<i>Product Recall</i>	123
Concluding Comments	126
Questions	126
CHAPTER 5 Order Processing and Information Systems	130
Defining Order Processing	131
<i>Order Preparation</i>	131
<i>Order Transmittal</i>	132
<i>Order Entry</i>	133
<i>Order Filling</i>	135
<i>Order Status Reporting</i>	136
Order-Processing Examples	137
<i>Industrial Order Processing</i>	137
<i>Retail Order Processing</i>	138
<i>Customer Order Processing</i>	139
<i>Web-Based Channel Order Planning</i>	141
Other Factors Affecting Order-Processing Time	145
<i>Processing Priorities</i>	145
<i>Parallel versus Sequential Processing</i>	145
<i>Order-Filling Accuracy</i>	146
<i>Order Batching</i>	146
<i>Lot Sizing</i>	146
<i>Shipment Consolidation</i>	146
The Logistics Information System	146
<i>Function</i>	146
<i>Internal Operation</i>	153
Information System Examples	156
<i>A Retail System</i>	156
<i>Vendor-Managed Inventory</i>	157

<i>E-Commerce</i>	159
<i>A Decision Support System</i>	160
Concluding Comments	161
Questions	161

PART III: TRANSPORT STRATEGY 164

CHAPTER 6 Transport Fundamentals 164

Importance of an Effective Transportation System	165
<i>Greater Competition</i>	165
<i>Economies of Scale</i>	166
<i>Reduced Prices</i>	166
Service Choices and Their Characteristics	167
<i>Price</i>	167
<i>Transit Time and Variability</i>	168
<i>Loss and Damage</i>	169
Single-Service Choices	171
<i>Rail</i>	171
<i>Truck</i>	172
<i>Air</i>	173
<i>Water</i>	174
<i>Pipeline</i>	175
Intermodal Services	176
<i>Trailer on Flatcar</i>	176
<i>Containerized Freight</i>	177
Agencies and Small Shipment Services	178
<i>Agents</i>	178
<i>Small-Shipment Services</i>	179
Company-Controlled Transportation	180
International Transportation	180
<i>Overview</i>	180
<i>Physical Plant</i>	181
<i>Agencies and Services</i>	183
Transport Cost Characteristics	184
<i>Variable and Fixed Costs</i>	185
<i>Common or Joint Costs</i>	185
<i>Cost Characteristics by Mode</i>	187
Rate Profiles	190
<i>Volume-Related Rates</i>	190
<i>Distance-Related Rates</i>	190
<i>Demand-Related Rates</i>	192
Line-Haul Rates	193
<i>By Product</i>	194

<i>By Shipment Size</i>	201
<i>By Route</i>	204
<i>Miscellaneous Rates</i>	204
Special Service Charges	205
<i>Special Line-Haul Services</i>	205
<i>Terminal Services</i>	210
Private Carrier Costing	211
Documentation	212
<i>Bill of Lading</i>	212
<i>Freight Bill</i>	213
<i>Freight Claims</i>	213
International Transport Documentation	214
<i>Exporting</i>	214
<i>Importing</i>	215
Concluding Comments	215
Questions	216

CHAPTER 7 Transport Decisions 219

Transport Service Selection	220
<i>Basic Cost Trade-Offs</i>	220
<i>Competitive Considerations</i>	222
<i>Appraisal of Selection Methods</i>	224
Vehicle Routing	225
<i>Separate and Single Origin and Destination Points</i>	225
<i>Multiple Origin and Destination Points</i>	230
<i>Coincident Origin and Destination Points</i>	232
Vehicle Routing and Scheduling	235
<i>Principles for Good Routing and Scheduling</i>	236
<i>Methods for Routing and Scheduling</i>	240
<i>Route Sequencing</i>	247
<i>Implementation of Vehicle Routing and Scheduling Methods</i>	248
<i>Ship Routing and Scheduling</i>	249
Freight Consolidation	252
Concluding Comments	254
Questions	254
Problems	255
<i>Case Study: Fowler Distributing Company</i>	267
<i>Case Study: Metrohealth Medical Center</i>	270
<i>Case Study: Orion Foods, Inc.</i>	276
<i>Case Study: R&T Wholesalers</i>	280

PART IV: INVENTORY STRATEGY 286

CHAPTER 8 Forecasting Supply Chain Requirements 286

Nature of Forecasting	287
<i>Spatial versus Temporal Demand</i>	287
<i>Lumpy versus Regular Demand</i>	288
<i>Derived versus Independent Demand</i>	288
Forecasting Methods	291
<i>Qualitative Methods</i>	291
<i>Historical Projection Methods</i>	291
<i>Causal Methods</i>	296
Useful Techniques for Logisticians	296
<i>Exponential Smoothing</i>	297
<i>Classic Time Series Decomposition</i>	305
<i>Multiple Regression Analysis</i>	309
Special Prediction Problems for Logisticians	310
<i>Start-Up</i>	310
<i>Lumpy Demand</i>	310
<i>Regional Forecasting</i>	311
<i>Forecast Error</i>	311
Collaborative Forecasting	314
Flexibility and Quick Response—An Alternative to Forecasting	316
Concluding Comments	317
Questions	317
Case Study: World Oil	323

CHAPTER 9 Inventory Policy Decisions 326

Appraisal of Inventories	328
<i>Arguments for Inventories</i>	328
<i>Arguments Against Inventories</i>	330
Types of Inventories	330
Classifying Inventory Management Problems	331
<i>Nature of Demand</i>	332
<i>Management Philosophy</i>	333
<i>Degree of Product Aggregation</i>	334
<i>Multi-Echelon Inventories</i>	334
<i>Virtual Inventories</i>	335
Inventory Objectives	335
<i>Product Availability</i>	336
<i>Relevant Costs</i>	337
Push Inventory Control	340
Basic Pull Inventory Control	342
<i>Single-Order Quantity</i>	342
<i>Repetitive Order Quantities</i>	344

Advanced Pull Inventory Control	348
<i>A Reorder Point Model with Uncertain Demand</i>	349
<i>The Reorder Point Method with Known Stockout Costs</i>	353
<i>The Reorder Point Method with Demand and Lead Time Uncertainty</i>	355
<i>A Periodic Review Model with Uncertain Demand</i>	357
<i>Practical Pull Inventory Control Methods</i>	363
Pipeline Inventories	374
Aggregate Control of Inventories	376
Supply-Driven Inventory Control	384
Virtual Inventories	385
Concluding Comments	389
Glossary of Terms	389
Questions	390
Problems	391
<i>Case Study: Complete Hardware Supply, Inc.</i>	403
<i>Case Study: American Lighting Products</i>	405
<i>Case Study: American Red Cross: Blood Services</i>	412
CHAPTER 10 Purchasing and Supply Scheduling Decisions	424
Coordination in the Supply Channel	425
Supply Scheduling	427
<i>Just-in-Time Supply Scheduling</i>	428
<i>Just-in-Time Distribution Scheduling</i>	442
Purchasing	446
<i>Importance of Purchasing</i>	447
<i>Order Quantities and Timing</i>	450
<i>Sourcing</i>	458
<i>Terms of Sale and Channel Management</i>	461
Concluding Comments	462
Questions	462
Problems	463
<i>Case Study: Industrial Distributors, Inc.</i>	468
CHAPTER 11 The Storage and Handling System	469
Need for a Storage System	470
Reasons for Storage	470
<i>Transportation-Production Cost Reduction</i>	470
<i>Coordination of Supply and Demand</i>	471
<i>Production Needs</i>	472
<i>Marketing Considerations</i>	472
Storage System Functions	472
<i>Storage Functions</i>	472
<i>Materials Handling Functions</i>	477

Storage Alternatives	479
<i>Space Ownership</i>	479
<i>Rented Space</i>	479
<i>Leased Space</i>	485
<i>Storage in Transit</i>	485
Materials Handling Considerations	486
<i>Load Unitization</i>	486
<i>Space Layout</i>	487
<i>Storage Equipment Choice</i>	490
<i>Movement Equipment Choice</i>	490
Storage System Costs and Rates	493
<i>Public Warehousing</i>	493
<i>Leased Warehousing, Manual Handling</i>	495
<i>Private Warehousing, Pallet and Forklift Truck Handling</i>	495
<i>Private Warehousing, Automated Handling</i>	495
Virtual Warehousing	496
Concluding Comments	499
Questions	499
CHAPTER 12 Storage and Handling Decisions	501
Site Selection	502
Planning for Design and Operation	503
<i>Sizing the Facility</i>	503
<i>Selecting the Space Type—Financial Considerations</i>	509
<i>Facility Configuration</i>	513
<i>Space Layout</i>	516
<i>Dock Design</i>	520
Materials Handling System Design	522
<i>Materials Handling System Selection</i>	523
<i>Equipment Replacement</i>	527
<i>Product Layout Decisions</i>	528
Order-Picking Operations	541
<i>Order Handling</i>	541
<i>Interleaving</i>	543
<i>Setting Standards</i>	543
Concluding Comments	544
Questions	544
Technical Supplement	549
PART V: LOCATION STRATEGY	550
CHAPTER 13 Facility Location Decisions	550
Classification of Location Problems	551
<i>Driving Force</i>	551
<i>Number of Facilities</i>	551