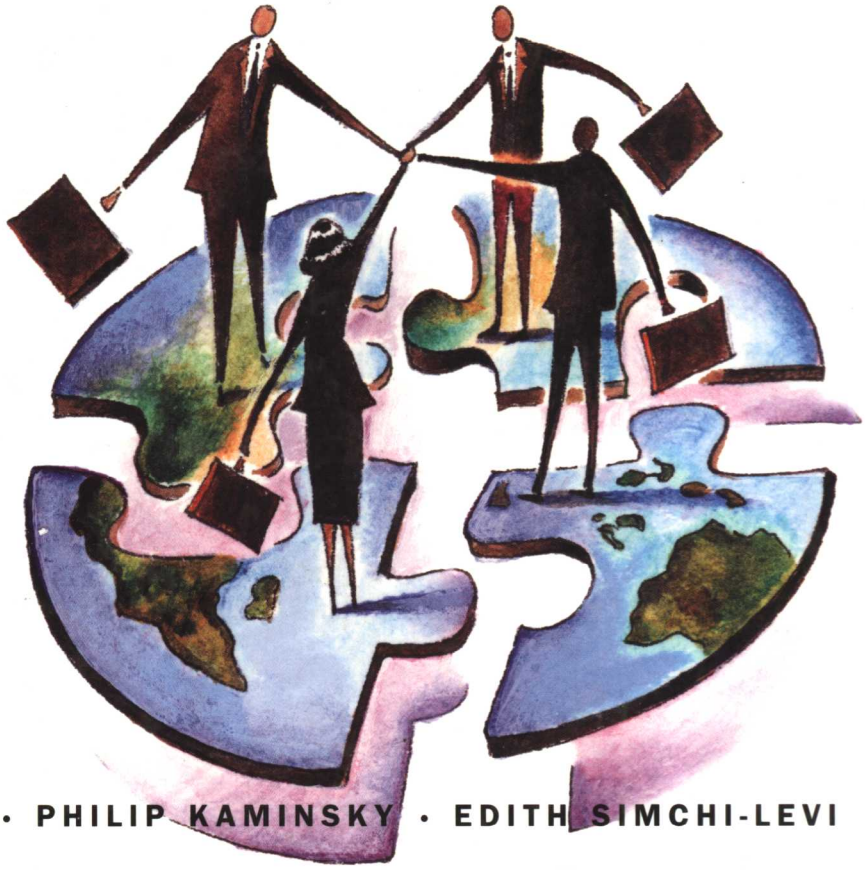
Designing and Managing the Supply Chain

Concepts, Strategies, and Case Studies



DAVID SIMCHI-LEVI · PHILIP KAMINSKY · EDITH SIMCHI-LEVI

"The book is an important contribution and major milestone for the supply chain community. It is the first book that covers a comprehensive breadth of supply chain topics in depth and addresses the major challenges in this area."

— Hau Lee, Stanford University
From the foreword to *Designing and Managing the Supply Chain: Concepts, Strategies, and Case Studies*

The importance of careful management of the supply chain has never been more critical. Corporations have begun to recognize that proper supply chain management can result in increased profits and reduced costs. Yet until now, few books have addressed supply chain issues as thoroughly and as thoughtfully as *Designing and Managing the Supply Chain: Concepts, Strategies, and Case Studies* by David Simchi-Levi, Philip Kaminsky, and Edith Simchi-Levi. Acknowledging the impact of high technology, transportation industry deregulation, and the increasing complexity of modern logistics, the authors examine critical supply chain issues pertinent to today's industrial environment. Pedagogical aids included in and with the textbook are:

- State-of-the-Art models
- Innovative Software:
  Computerized Beer Game and *Risk Pool Game*
- Case Studies

OMC
Operations Management Center

Visit our Operations Management Center at **www.mhhe.com/pom/** for

- Current articles and readings
- Links to company tours
- Resources by topic
- Contact operations management organizations
- Download software

McGraw-Hill Higher Education
A Division of The McGraw-Hill Companies

P/N 0-256-26168-7
Part of
ISBN 0-07-235756-8
90000
9 780072 357561
www.mhhe.com

Designing and Managing the Supply Chain

Concepts, Strategies, and Case Studies

David Simchi-Levi
Northwestern University, Evanston, Illinois

Philip Kaminsky
University of California, Berkeley

Edith Simchi-Levi
LogicTools, Inc., Northbrook, Illinois

Irwin McGraw-Hill

Boston Burr Ridge, IL Dubuque, IA Madison, WI New York San Francisco St. Louis
Bangkok Bogotá Caracas Lisbon London Madrid
Mexico City Milan New Delhi Seoul Singapore Sydney Taipei Toronto

McGraw-Hill Higher Education
A Division of The McGraw-Hill Companies

DESIGNING AND MANAGING THE SUPPLY CHAIN
CONCEPTS, STRATEGIES, AND CASE STUDIES

This book is printed on acid-free paper.

3 4 5 6 7 8 9 0 FGR/FGR 9 0 9 8 7 6 5 4 3 2 1 0

ISBN 0-256-26168-7

Vice president/Editor-in-Chief: *Michael W. Junior*
Publisher: *Jeffrey J. Shelstad*
Senior sponsoring editor: *Scott Isenberg*
Editorial coordinator: *Nicolle Schieffer*
Senior marketing manager: *Colleen J. Suljic*
Project manager: *Kimberly Moranda*
Manager, new book production: *Melonie Salvati*
Designer: *Suzanne Montazer*
Supplement coordinator: *Rose M. Range*
New media: *Charles Pelto*
Compositor: *Techsetters, Inc.*
Typeface: *10/12 Palatino*
Printer: *Quebecor Printing Book Group/Fairfield*

Library of Congress Cataloging-in-Publication Data

Simchi-Levi, David.
Designing and managing the supply chain / David Simchi-Levi, Philip Kaminsky, Edith Simchi-Levi.
p. cm.
Includes bibliographical references and index.
ISBN 0-07-028594-2
1. Physical distribution of goods—Management. 2. Marketing channels—Management. 3. Business logistics. 4. Industrial procurement. I. Kaminsky, Philip. II. Simchi-Levi, Edith. III. Title.
HF5415.7.S425 2000
658.5—dc21 99-31791

http://www.mhhe.com

THE IRWIN/MCGRAW-HILL SERIES
Operations and Decision Sciences

OPERATIONS MANAGEMENT

Bowersox and Closs, **Logistical Management: The Integrated Supply Chain Process**, *First Edition*
Chase, Aquilano, and Jacobs, **Production and Operations Management**, *Eighth Edition*
Chu, Hottenstein, and Greenlaw, **PROSIM for Windows**, *Third Edition*
Cohen and Apte, **Manufacturing Automation**, *First Edition*
Davis, Aquilano, and Chase, **Fundamentals of Operations Management**, *Third Edition*
Dobler and Burt, **Purchasing and Supply Management**, *Sixth Edition*
Flaherty, **Global Operations Management**, *First Edition*
Fitzsimmons and Fitzsimmons, **Service Management: Operations, Strategy, Information Technology**, *Second Edition*
Gray and Larson, **Project Management: The Managerial Process**, *First Edition*
Hill, **Manufacturing Strategy: Text & Cases**, *Third Edition*
Hopp and Spearman, **Factory Physics**, *Second Edition*
Lambert and Stock, **Strategic Logistics Management**, *Third Edition*
Leenders and Fearon, **Purchasing and Supply Chain Management**, *Eleventh Edition*
Melnyk and Denzler, **Operations Management**, *Second Edition*
Moses, Seshadri, and Yakir, **HOM Operations Management Software for Windows**, *First Edition*
Nahmias, **Production and Operations Analysis**, *Third Edition*
Nicholas, **Competitive Manufacturing Management**, *First Edition*
Pinedo and Chao, **Operations Scheduling**, *First Edition*
Sanderson and Uzumeri, **Managing Product Families**, *First Edition*
Schroeder, **Operations Management: Contemporary Concepts and Cases**, *First Edition*
Schonberger and Knod, **Operations Management: Customer-Focused Principles**, *Sixth Edition*
Simchi-Levi, Kaminsky, Simchi-Levi, **Designing and Managing the Supply Chain: Concepts, Strategies, and Case Studies**, *First Edition*
Sterman, **Business Dynamics: Systems Thinking and Modeling for a Complex World**, *First Edition*
Stevenson, **Production/Operations Management**, *Sixth Edition*
Vollmann, Berry, and Whybark, **Manufacturing Planning & Control Systems**, *Fourth Edition*
Zipkin, **Foundations of Inventory Management**, *First Edition*

QUANTITATIVE METHODS AND MANAGEMENT SCIENCE

Bodily, Carraway, Frey, Pfeifer, **Quantitative Business Analysis: Casebook**, *First Edition*
Bodily, Carraway, Frey, Pfeifer, **Quantitative Business Analysis: Text and Cases**, *First Edition*
Bonini, Hausman, and Bierman, **Quantitative Analysis for Business Decisions**, *Ninth Edition*
Hesse, **Managerial Spreadsheet Modeling and Analysis**, *First Edition*
Hillier, Hillier, Lieberman, **Introduction to Management Science: A Modeling and Case Studies Approach with Spreadsheets**, *First Edition*

About the Authors

David Simchi-Levi is Professor of Industrial Engineering and Management Science at Northwestern University. Prior to joining the faculty at Northwestern, he taught at Columbia University. Professor Simchi-Levi received his Ph.D. in operations research from Tel-Aviv University and has won awards for his work in supply chain, logistics, and transportation. He is the co-author, with Julien Bramel, of *The Logic of Logistics*, published by Springer-Verlag, and the founder and chairman of LogicTools, Inc., a company that provides decision support software for supply chain and logistics management.

Philip Kaminsky is Assistant Professor of Industrial Engineering at the University of California at Berkeley. He received his Ph.D. in Industrial Engineering from Northwestern University. Prior to his graduate studies, he worked for the production division of Merck & Co., Inc. He has consulted in the areas of supply chain and production management.

Edith Simchi-Levi is President of LogicTools, Inc. She received her B.S. in Mathematics and Computer Science from Tel-Aviv University. She has extensive experience in software development and numerous consulting projects in logistics and supply chain management.

Foreword

In the last few years we have seen an explosion of publications on supply chain management; numerous books have been published and many articles have appeared in academic, trade, and popular magazines. These publications are either too technical—and therefore inaccessible to practitioners and students—or they lack the breadth and depth that the topic deserves. Certainly, it is difficult to find a book appropriate for teaching supply chain management to business or engineering students. *Designing and Managing the Supply Chain* solves this problem!

The book is an important contribution and major milestone for the supply chain community. It is the first book that covers a comprehensive breadth of supply chain topics in depth, and addresses the major challenges in this area. It was written by experts from academia and industry who have been researching, consulting, and developing software for supply chain management for many years.

This book includes many classic and new case studies, numerous examples as well as in-depth analysis of some of the technical issues involved in inventory management, network design, and strategic partnering, to name a few. It is therefore an ideal textbook for classes on supply chain management at the undergraduate, Master's, and M.B.A. levels. Since each chapter is self-contained, instructors can pick the chapters they want to use, depending on the length of the class and its requirements. The book comes with two computerized games. The Computerized Beer Game provides an excellent instructional tool that engages students in managing a supply chain and provides a starting point for discussing the value of information in the supply chain, strategic partnering, centralized decision making, etc. The Risk Pool Game allows students to gain insight on an

important concept in supply chain management, called risk pooling. The authors have been most creative in using games to motivate and expose students to challenging subjects.

Finally, since many companies view supply chain management as the core of their business strategy, this book will also be of interest to managers involved in any of the processes that make up the supply chain.

I want to compliment the authors for having written such an outstanding textbook for the supply chain community.

Hau L. Lee
Kleiner Perkins, Mayfield, Sequoia Capital Professor
Director, Stanford Global Supply Chain Forum
Stanford University

Preface

This book grew out of a number of supply chain management courses and Executive Education programs we have taught at Northwestern University over the past several years, as well as numerous consulting projects and supply chain decision-support systems we have developed at LogicTools. The courses, taught in the Master of Management in Manufacturing (M.M.M.) program, a joint M.B.A. program between the Kellogg School of Business and McCormick School of Engineering at Northwestern University, and in Executive Education programs sponsored by Kellogg, have spawned many innovative and effective supply chain education concepts. The focus in these programs has been on presenting, in an easily accessible manner, recently developed state-of-the-art models and solution methods important in the design, control, and operation of supply chains. The consulting projects and decision-support systems developed by LogicTools have focused on applying these advanced techniques to solve specific problems faced by our clients.

Interest in supply chain management, both in industry and in academia, has grown rapidly over the past several years. A number of major forces have contributed to this trend. First, in recent years it has become clear that many companies have reduced manufacturing costs as much as practically possible. Many of these companies are discovering the magnitude of savings that can be achieved by planning and managing their supply chain more effectively. Indeed, a striking example is Wal-Mart's success, which is partly attributed to implementing a new logistics strategy called cross-docking. At the same time, information and communication systems have been widely implemented, and provide access to comprehensive data from all components of the supply chain. Finally, deregulation of the

transportation industry has led to the development of a variety of transportation modes and reduced transportation costs, while significantly increasing the complexity of logistics systems.

It is therefore not surprising that many companies are involved in the analysis of their supply chains. In most cases, however, this analysis is performed based on experience and intuition; very few analytical models or design tools have been used in this process. In contrast, in the last two decades the academic community has developed various models and tools for supply chain management. Unfortunately, the first generation of this technology was not robust or flexible enough to allow industry to use it effectively. This, however, has changed over the last few years during which improved analysis and insight, and effective models and decision-support systems, have been developed, but these are not necessarily familiar to industry. Indeed, to our knowledge there is no published work that discusses these problems, models, concepts, and tools at an appropriate level.

In this book, we intend to fill this gap by providing state-of-the-art models, concepts, and solution methods important in the design, control, operation, and management of supply chain systems. In particular, we have attempted to convey both the intuition behind many key supply chain concepts and to provide simple techniques that can be used to analyze various aspects of the supply chain.

The emphasis is on a format that will be accessible to executives and practitioners, as well as students interested in careers in related industries. In addition, it will introduce readers to information systems and decision-support tools that can aid in the design, analysis, and control of supply chains.

The book is written to serve as:

- A textbook for M.B.A.-level logistics and supply chain management courses.
- A textbook for B.S. and M.S. industrial engineering courses on logistics and supply chain management.
- A reference for teachers, consultants, and practitioners involved in any one of the processes that make up the supply chain.

Of course, supply chain management is a very broad area, and it would be impossible for a single book to cover all of the relevant areas in depth. Indeed, there is considerable disagreement in academia and industry about exactly what these relevant areas are. Nevertheless, we have attempted to provide a broad introduction to many critical facets of supply chain management. Although many essential supply chain management issues are interrelated, we have strived wherever possible to make each chapter as self-contained as possible, so that the reader can refer directly to chapters covering topics of interest. The discussion ranges from basic topics of in-

ventory management, logistics network design, distribution systems, and customer value to more advanced topics of strategic alliances, the value of information in the supply chain, information technology and decisions support systems, and international issues in supply chain management. Each chapter utilizes numerous case studies and examples, and mathematical and techical sections can be skipped without loss of continuity.

In addition, the book includes two software packages, the **Computerized Beer Game** and the **Risk Pool Game**, which help to illustrate many of the concepts we discuss in the book. Indeed, in teaching executives and M.B.A. students we have found that these games help students better understand issues and concepts such as the bullwhip effect, the value of information in the supply chain, and the impact of lead times, centralized decision making, and risk pooling on supply chain operations.

Parts of this book are based on work we have done either together or with others. Chapters 1 and 2 borrow extensively from *The Logic of Logistics*, written by Julien Bramel and David Simchi-Levi and published by Springer in 1997. This, of course, is done by permission of the copyright owner. The Computerized Beer Game is discussed in an article by Philip Kaminsky and David Simchi-Levi which appeared in *Supply Chain and Technology Management*, edited by Hau Lee and Shu Ming Ng and published by The Production and Operations Management Society. Some of the material on the bullwhip effect appears in an article by Chen, Drezner, Ryan, and Simchi-Levi in *Quantitative Models for Supply Chain Management*, edited by Sridhar Tayur, Ram Ganeshan, and Michael Magazine, and published by Kluwer Academic Publishers.

Acknowledgments

It is our pleasure to acknowledge all those who helped us with this manuscript. First, we would like to thank Dr. Myron Feinstein, former director of supply chain strategy development at Unilever, New York City, who read through and commented on various chapters. Similarly, we are indebted to the reviewers, Professors Michael Ball (University of Maryland), Wendell Gilland (University of North Carolina, Chapel Hill), Eric Johnson (Vanderbilt University), Douglas Morrice (The University of Texas, Austin), Michael Pangburn (Pennsylvania State University), Powell Robinson (Texas A&M University), William Tallon (Northern Illinois University), and Rachel Yang (University of Illinois, Urbana-Champaign). Their comments were invaluable in improving the organization and presentation of the book. We are also grateful to Deniz Caglar, a Ph.D. candidate at Northwestern University, for his comments on earlier drafts of the book. In addition, we thank Dr. Kathleen A. Stair and Ms. Ann Stuart for carefully editing and proofreading many chapters.

Finally, we wish to thank Ms. Colleen Tuscher, who assisted us in the initial stage of the project, our editor, Mr. Scott Isenberg, and his assistant, Ms. Nicolle Schieffer, of Irwin/McGraw-Hill, who encouraged us throughout and helped us complete the book. Also, thanks to Ms. Kimberly Moranda and the production staff at McGraw-Hill for their help.

David Simchi-Levi, Evanston, Illinois
Philip Kaminsky, Berkeley, California
Edith Simchi-Levi, Northbrook, Illinois

List of Cases

Brief Contents

Contents