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The Logic of Logistics

Theory, Algorithms, and Applications for Logistics and Supply Chain Management

Second Edition

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Preface

Seven years ago, when we wrote the first edition of this text, our objective was to present, in an easily accessible manner, logistics and supply chain models, algorithms and tools. The success of that edition, as well as new theory, algorithms and recent technological changes, have motivated us to revise the book. In this edition, we have attempted to build on the positive elements of the first edition, and to include what we have learned in the last few years.

The first edition of the book grew out of a number of distribution and logistics graduate courses we have taught over a period of about ten years. In the first few years, the emphasis was on very basic models such as the traveling salesman problem, and on the seminal papers of Haimovich and Rinnooy Kan (1985), which analyzed a simple vehicle routing problem, and Roundy (1985), which introduced power-of-two policies and proved that they are effective for the one warehouse multi-retailer distribution system. At that time, few results existed for more complex, realistic distribution problems, stochastic inventory problems or the integration of these issues.

Interest in logistics and supply chain management, both in industry and in academia, has grown rapidly over the past several years. A number of forces have contributed to this trend. First, 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.

In particular, the influence of the Internet and E-commerce on the economy in general, and business practice in particular, has been tremendous. Changes are happening extremely fast and the scope is breathtaking! For instance, the Direct-Business-Model employed by industry giants such as Dell Computers and Amazon.com, enables customers to order products over the Internet and thus allows companies to sell their products without relying on third party distributors or conventional stores.

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.

These developments have motivated the academic community to aggressively pursue answers to supply chain research questions. Indeed, in the last five years considerable progress has been made in the analysis and solution of logistics and supply chain problems.

This progress was achieved using a variety of techniques. In some cases, the focus is on characterizing the structure of the optimal policy and identifying algorithms that generate the best possible policies. When this is not possible, the focus has been on an approach whose purpose is to ascertain characteristics of the problem or of an algorithm that are *independent of the specific problem data*. That is, the approach determines characteristics of the solution or the solution method that are intrinsic to the problem and not the data. This approach includes the so-called worst-case and average-case analyses which, as illustrated in the book, help not only to understand characteristics of the problem or solution methodology, but also provide specific guarantees of effectiveness. In many cases, the insights obtained from these analyses can then be used to develop practical and effective algorithms for specific complex logistics problems. Our objective in writing this book is to describe these tools and developments.

Of course, the work presented in this book is not necessarily an exhaustive account of the current state of the art in logistics and supply chain management. The field is too vast to be properly covered here. In addition, the practitioner may view some of the models discussed as simplistic and the analysis presented as complex. Indeed, this is the dilemma one is faced with when analyzing very complex, multi-faceted, real-world problems. By focusing on simple yet rich models that contain important aspects of the real-world problem, we hope to glean important characteristics of the problem that might be overlooked by a more detail-oriented approach.

The book is written for graduate students, researchers and practitioners interested in the *mathematics of logistics and supply chain management*. We assume the reader is familiar with the basics of linear programming and probability theory and, in a number of sections, complexity theory and graph theory, although in many cases these can be skipped without loss of continuity. The first edition of the book focused on:

- A thorough treatment of performance analysis techniques including worst-case analysis, probabilistic analysis and linear programming based bounds.

- An in-depth analysis of a variety of vehicle routing models focusing on new insights obtained in recent years.
- A detailed, easy-to-follow analysis of complex inventory models.
- A model that integrates inventory control and transportation policies and explains the observed effectiveness of the cross-docking strategy.
- A description of advance planning systems for planning and managing important aspects of the logistics system.

We have made substantial changes to the second edition of this text. As we continued to teach, consult and research supply chain management issues, we have placed an increasing importance on developing effective models for supply chain planning, coordination and execution. This is reflected in the second edition; we have added a number of chapters and changed the material in some of the original chapters to reflect current logistics and supply chain challenges. For example:

- We added a chapter on Convexity and Supermodularity, two important concepts in the optimization and economics literature (Chapter 2).
- We added a chapter on Procurement Contracts (Chapter 10).
- We added a chapter on Supply Chain Planning models (Chapter 11).
- We added a chapter on the coordination of inventory replenishment and pricing strategies (Chapter 9).
- We cover risk management models (Chapter 9).
- We significantly revised the portion of the book that covers classical inventory models (Chapters 6-8). In particular, we revised the analysis of stochastic inventory models, both for single facility and multi-echelon supply chains.
- We added a chapter on Network Planning (Chapter 17) focusing on supply chain design, inventory positioning and resource utilization.

Parts of this book are based on work we have done either together or with others. Indeed, some of the chapters originated from papers we have published in journals such as *Mathematics of Operations Research*, *Mathematical Programming, Operations Research*, and *IIE Transactions*. We rewrote most of these, trying to present the results in a simple yet general and unified way. However, a number of key results, proofs and discussions are reprinted without substantial change. Of course, in each case this was done by providing the appropriate reference and by obtaining permission of the copyright owner. In the case of *Operations Research* and *Mathematics of Operations Research*, it is the Institute for Operations Research and Management Science. Chapters 11 borrows extensively from "Supply Chain Design and Planning - Applications of Optimization Techniques for Strategic and Tactical Models" written by Ana Muriel and David Simchi-Levi and published

in the *Handbooks in Operations Research and Management Science*, the volume on *Supply Chain Management*, S. Graves and A. G. Kok, eds., North-Holland, Amsterdam. Similarly, Chapter 17 borrows extensively from *Designing and Managing the Supply Chain*, written by David Simchi-Levi, Philip Kaminsky and Edith Simchi-Levi and published by McGraw-Hill 2003.

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