Process Systems Engineering

Edited by Efstratios N. Pistikopoulos, Michael C. Georgiadis, and Vivek Dua

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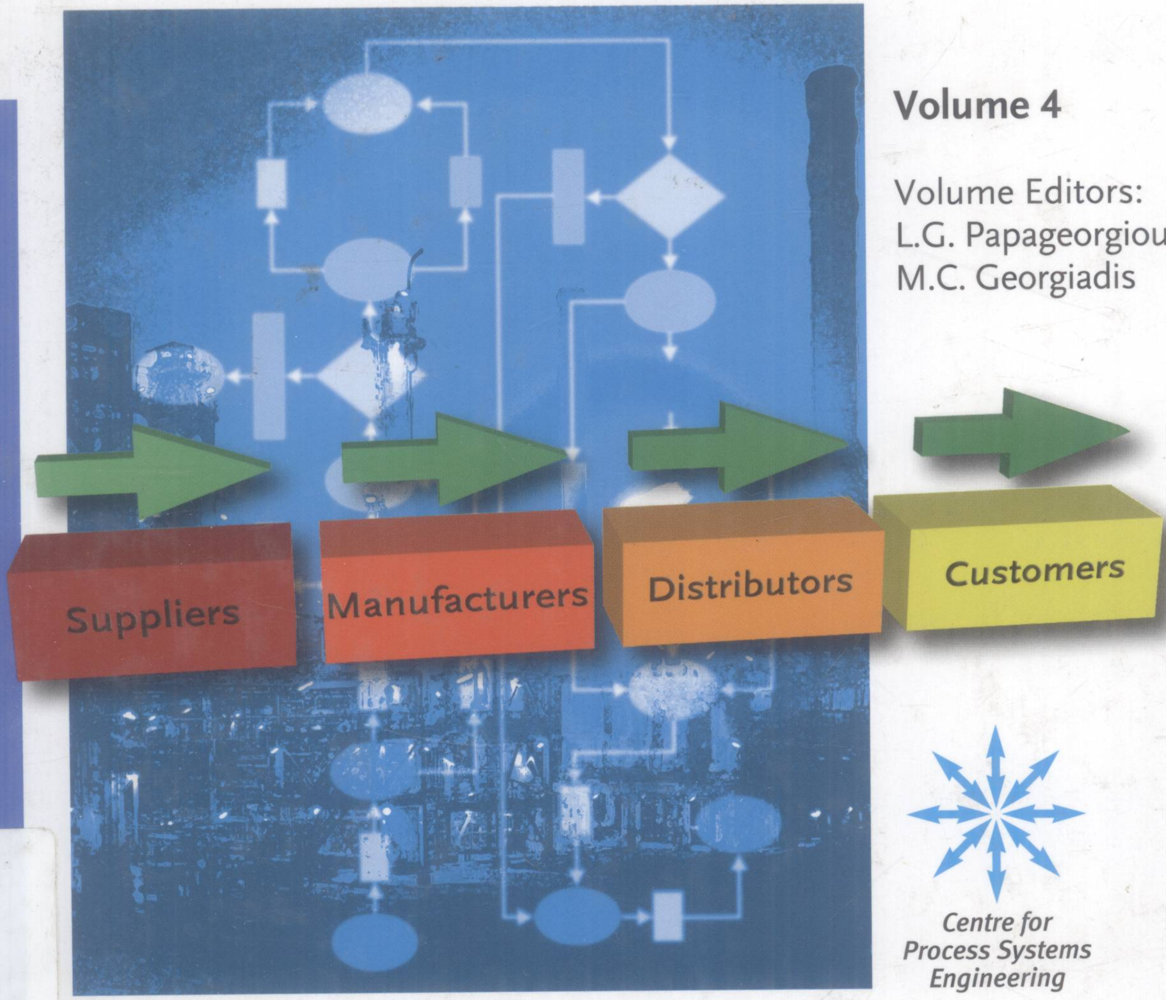
Supply Chain Optimization

Part II



Volume 4

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L.G. Papageorgiou,
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Centre for Process Systems Engineering

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Volume 4: Supply Chain Optimization, Part II
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Lazaros G. Papageorgiou and Michael C. Georgiadis

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Preface – Volume 4: Supply Chain Optimization

Modern industrial enterprises are typically multiproduct, multipurpose, and multisite facilities operating in different regions and countries and dealing with a globalwide international clientele. In such enterprise networks, the issues of global enterprise planning, coordination, cooperation and robust responsiveness to customer demands at the global as well as the local level are critical for ensuring effectiveness, competitiveness, business sustainability, and growth. In this context, it has long been recognized that there is a need for efficient integrated approaches that consider, in a systematic way, various levels of enterprise management, plant-wide coordination and plant operation, in order to reduce capital and operating costs, increase supply chain productivity and improve business responsiveness.

The supply chain concept has in recent years become one of the main approaches to achieve enterprise efficiency. The terminology implies that a system view is taken rather than a functional or hierarchical one. Enterprises cannot be competitive without considering supply chain activities. This is partially due to the evolving higher specialization in a more differentiated market. Most importantly, competition drives companies to reduced cost structures with lower inventories, more effective transportation systems, and transparent systems able to support information throughout the supply chain. A single company rarely controls the production of a commodity as well as sourcing, distribution, and retail.

Many typical supply chains today have production that spans several countries and product markets. The opportunities for supply chain improvements are large. Costs of keeping inventory throughout the supply chain to maintain high customer service levels are generally significant. There is a wide scope to reduce the inventory while still maintaining the high service standards required. Furthermore, the manufacturing processes can be improved so as to employ current working capital and labor more efficiently.

It has widely been recognized that enhanced performance of supply chains necessitates: (i) appropriate design of supply chain networks and its components and (ii) effective allocation of available resources over the network. Thus, in the last few years, there has been a multitude of efforts focused on providing improvements of supply chain management and optimization. These efforts include a wide range of models: from commercial enterprise resource planning systems and so-

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called advanced planning systems to academic achievements (for example, linear and mixed-integer programming, multiagent systems).

Management of supply chains is a complex task mainly due to the large size of the physical supply network and inherent uncertainties. In a highly competitive environment, improved decisions are required for efficient supply chain management at strategic, tactical, and operational levels with time horizons ranging from several years to a few days, respectively. Depending on the level, one or more of the following decisions are taken:

- Number, size and location of manufacturing sites, warehouses and distribution centers.
- Network connectivity (e.g., allocation of suppliers to plants, warehouses to markets, etc.).
- Production decisions related to plant production planning and scheduling.
- Management of inventory levels and replenishment policies.
- Transportation decisions concerning mode of transportation (e.g., road, rail, etc.) and also size of material shipment.
- Sustainability aspects (e.g., environmental impact considerations, recycling policies, etc.).

Most of the above challenging research issues are addressed in Volumes 3 and 4 of this book series.

Volume 4 provides a comprehensive review of key research contributions concerning tactical and operational decisions of supply chain problems for the process industries.

Sousa, Shah, and Papageorgiou in Chapter 1 address a systematic optimization-based supply chain planning model of large process industrial companies of products with a high added value per mass unit. Here, transportation costs have a reduced impact in the total expenditure in supply chain activities, from raw material supply until distribution to final markets. A case study relevant to the pharmaceutical industry is presented concerning production allocation to manufacturing sites in a worldwide network. Both deterministic and stochastic cases are addressed and compared. The large, mixed-integer linear programming (MILP) models generated were efficiently solved using a temporal decomposition algorithm.

Dondo, Méndez, and Cerda in Chapter 7 consider an MILP-based mathematical formulation focused on the operational level of multiple vehicle pickup and delivery problems with time windows commonly arising in multisite systems. The proposed two-index model can be solved using a branch-and-cut commercial package to find the best vehicle routes and schedules for moderate-size problems. The formulation has been generalized to also consider pure pickup and delivery nodes, heterogeneous vehicles, multiple depots, as well as many-to-many transportation requests. To tackle medium-size problems, several preordering and variable and constraint elimination rules are introduced. Optimal solutions for a variety of benchmark problems featuring different sizes in terms of customer requests and vehicles, distinct cluster/random pickup and delivery locations and a range of time-window width distributions are reported.

Pratikakis, Realff, and Lee in Chapter 3, present a real-time approximate dynamic programming approach for the efficient solution of multistage supply chain decision problems under a stochastic environment. The supply chain system experiences stochastic variations in demand and price of the main products which are modeled using Markov chains. The main idea of the overall methodology is to start with a heuristic policy derived from an MILP formulation and to gradually construct a superior quality solution by interacting with the stochastic system via simulation.

Disruptions could bring about adverse effects such as blockage of material, information, and finance flows, loss of production, off-spec products, loss of efficiency, under- or oversupply, etc. Any of these could result in operational problems, loss of business opportunities, and financial losses. A deviation between plan and actual realization occurs during disruptions. Depending on the magnitude of the deviation, the necessary response would have to differ. Adhitya, Srinivasan, and Karimi in Chapter 4 first describe the crude oil supply chain and clearly state the rescheduling problem. Two new rescheduling methods are then presented to address supply chain disruptions. A petroleum refinery supply chain is used to identify the salient characteristics of the problem and review solution methods.

The group of Bandoni and coworkers in Chapter 5 propose a detailed and complete tactical planning model to aid in the negotiation instance of a typical large company that operates several nodes of the fruit industry supply chain. The proposed linear programming model considers the many interactions of the real network and the typical operative practices of the business. A real-world case study from the pip fruit industry of Argentina is used to illustrate the applicability of the proposed model.

The research area of batch and continuous process scheduling has received great attention from both academia and industry in the past two decades. This is motivated by the increasing pressure to improve efficiency and reduce costs, and by the significant advances in relevant modeling and solution techniques and the rapidly growing computational power. Shaik and Floudas in Chapter 6 present a comprehensive overview of the recent developments in scheduling of multiproduct, multipurpose batch, and continuous processes. Different continuous-time based scheduling models from the literature are discussed, followed by a comparative study of these methods on some benchmark examples.

Jia and Ierapetritou in Chapter 7 address the problem of refinery scheduling under uncertainty through a multiobjective optimization and a parametric integer linear programming approach. Several case studies considering the optimal operations of crude oil unloading and mixing, and gasoline blending and distributions are presented to illustrate the importance of considering uncertainty in demand in refinery scheduling operations.

Westerlund and coworkers in Chapter 8 present an MILP-based tool for the production and intermediate planning in the tissue manufacturing industry. The tool is based on a mixed-time scheduling formulation, implementing tailored software architecture as an access point to various information systems at the mill. The tool is furthermore integrated into a user-friendly interface and is concerned with the production and raw material cost minimization, as well as intermediate storage utilization at the stock preparation section.

Sung and Maravelias in Chapter 9 provide a review of the methods that have been proposed for the solution of production planning problems in the chemical industry. First, the classical formulations used in Operations Research and the main software tools currently used in practice are discussed. Second, modeling approaches and optimization strategies for the integration of production planning with scheduling are presented. Finally, a brief discussion of specific applications and the integration of production planning with other models is analyzed.

In the final chapter, Ydstie and coworkers study inventory and control flows in complex supply chains using approaches developed in the area of process control. New methods for inventory control are introduced using frequency response analysis and an approach for feedback scheduling of assembly, disassembly, and repackaging lines is investigated. Furthermore, a method for control is developed which optimizes the intrinsic value of a business by managing inventory and flows so that costs are minimized.

This collection represents a set of stand-alone works that captures recent research trends in the development and application of techniques, methodologies, algorithms, and tools for optimizing various aspects of supply chain systems. We hope that by the end of the book, the reader will have developed a commanding comprehension of the main aspects of integrated supply chains, the ability to critically access the key characteristics and elements related to the design and operation of supply chains, and the capacity to implement the new technology in practice.

We are extremely grateful to the authors for their outstanding contributions and for their patience, which have led to a final product that far exceeded our expectations.

London, June 2007
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