Process Systems Engineering

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

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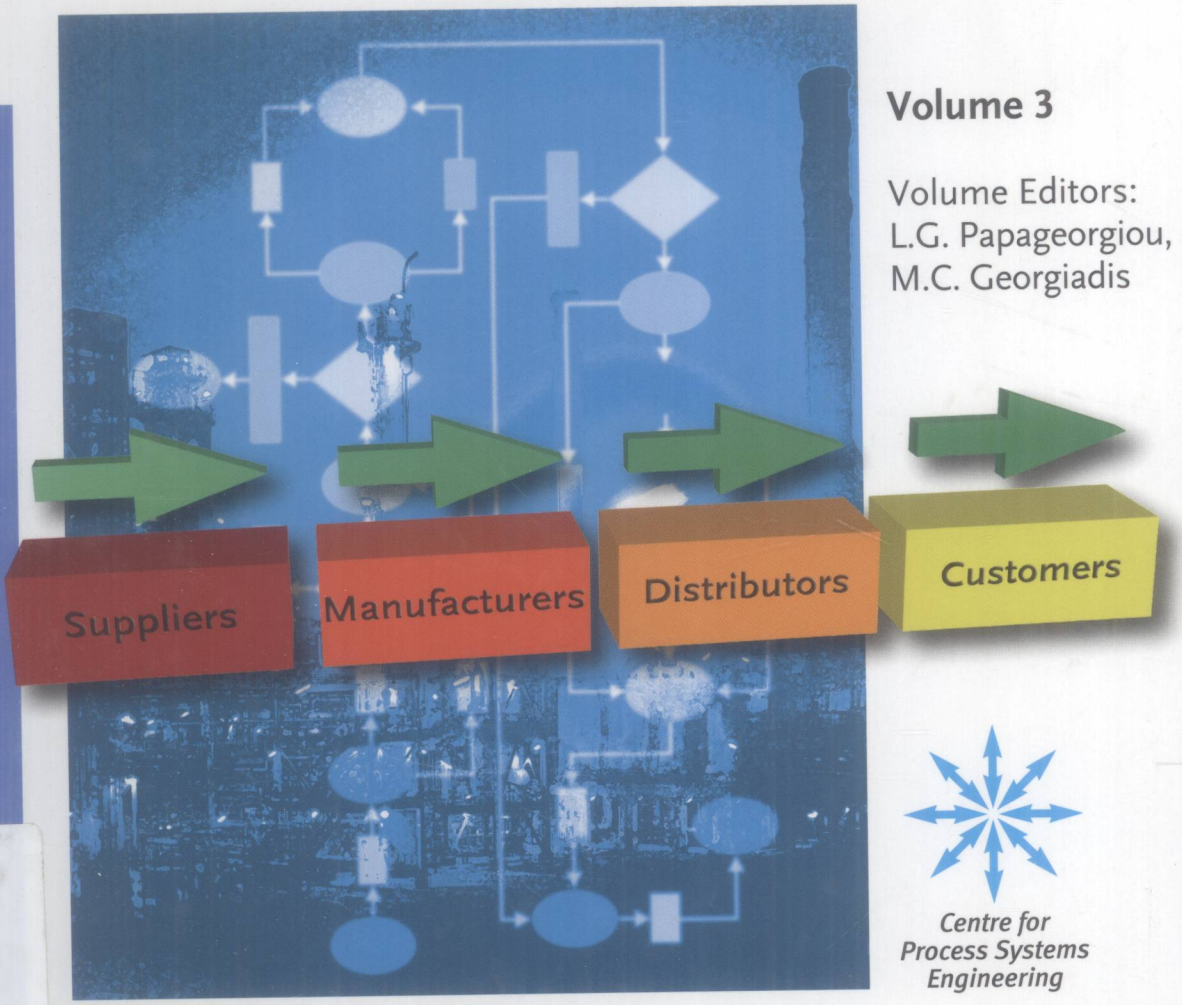
Supply Chain Optimization

Part I



Volume 3

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L.G. Papageorgiou,
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Centre for
Process Systems
Engineering

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Volume 3: Supply Chain Optimization, Part I
Volume Edited by
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Preface – Volume 3: Supply Chain Optimization

Modern industrial enterprises are typically multiproduct, multipurpose, and multisite facilities operating in different regions and countries and dealing with a global-wide 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 3 of this book series focuses on strategic and tactical supply chain planning with emphasis on the process industries.

The need to incorporate financial considerations in the design and operation of supply chains has long been recognized and it is addressed in Chapter 1 by Puigjaner and coworkers. In the first part of their work, they present a systematic mathematical programming framework that incorporates financial considerations at the tactical and strategic supply chain decision-making levels. In the second part, different techniques are described that aim to manage risk associated with the operation of supply chain systems under uncertainty. In the subsequent chapter, the same authors describe a new simulation-based modeling technique for taking supply chain management (SCM) decisions by utilizing software agents as building blocks. The resulting agent-based system is a discrete event simulator that is able to use a number of tools such as if-then rules and mathematical programming algorithms. Furthermore, an alternative strategy for tackling SCM decision is developed, which is based on metaheuristic rules applied in the multiagent simulator. The resulting tool is flexibile enough to accommodate further extensions and details of integrated supply chains.

Türkay in Chapter 3 presents an integrated approach to ensure an environmentally conscious performance of supply chain systems in addition to the economical performance. Three different approaches are considered and modeled: (i) the product-centric approach involves avoiding the use of environmentally harmful materials in the product at the product design stage and the recovery and reuse of the product after it has been consumed by the end user; (ii) the production-system-centric approach considers the selection of raw materials and the design

of the production systems for minimizing the environmental impact; and (iii) the transportation-centric approach focuses on the use of different transportation systems that would reduce the environmental effects.

You and Grossmann consider in Chapter 4 the problem of optimal design and operational planning of multiechelon, multisite process supply chain networks with consideration of responsiveness and profitability. The problem is formulated as a bicriterion optimization model in which the objectives are to maximize the net present value and to minimize the lead time. This allows establishing trade-offs between the economics and responsiveness of the supply chain network. The model produces a Pareto-optimal curve, which reveals how the optimal net present value, and therefore the network structure of the supply chains, changes with different specifications of lead time.

The work of Assavapokee, Realff, and Ammons described in Chapter 5 is motivated by the increasing pressure to design large scale recovery and recycling systems for electronics, carpet, and other complex products with relatively low value at their end-of-life. A supply chain mathematical programming model is proposed for reverse production system design for carpet recycling. The overall modeling and optimization approach can inform decision makers as to where to focus their efforts in recruitment of sources of material and the overall target costs that are achievable.

In Chapter 6, Tsiakis, Papageorgiou, and Georgiadis present the application of a mixed-integer linear programming (MILP) model on two real examples where the aim is to determine the optimal configuration of a production and distribution network subject to operational and financial constraints. Operational constraints include quality, production and supply restrictions, and are related to the allocation of the production and the workload balance between production sites. Financial constraints include production costs, transportation costs, and duties for the material flowing within the network subject to exchange rates. As a business decision the outsourcing of production is considered whenever the organization cannot satisfy the demand.

The group of Barbosa and coworkers in Chapter 7 propose a generic modeling approach for the design and planning of closed-loop supply chains. This considers the simultaneous analysis of both strategic and tactical decisions where the system structure is defined taking into account the planning of the related logistic activities. Several challenging problems in the area of reverse and closed-loop supply chains are critically discussed.

Kallrath in Chapter 8 presents an integrated modeling framework addressing various conceptual issues in strategic, multisite design, and planning problems in the process industry. The need for a combined design and operative planning model is emphasized and efficient tailored-made modeling and solution techniques for real-world problems are discussed. Finally, several problems for supply chain planning and design in large companies focusing on the needs for appropriate modeling and maintainable IT structures are highlighted.

Naraharisetti, Karimi, and Srinivasan in Chapter 9 present a novel MILP model for making efficient capacity management and supply chain redesign decisions

for a multinational corporation. The model can provide the basis for obtaining the best strategy for investment, involving a variety of real decisions such as facility relocation, disinvestment, technology upgrade, raising capital through loans and bonds, and hedging risk through signing contracts for material supply. The same model can repeatedly be used to analyze various probabilistic scenarios and thus make the choice of implementing one of the various resulting plans. A realistic case study was used to illustrate the benefits that can be achieved by using the developed model.

Pinto and coworkers in Chapter 10 present a hybrid algorithm for the solution of mixed-integer linear programming problems in which a small subset of the discrete variables account for most of the computational complexity of the model. The algorithm builds upon the parametric tabu-search procedure proposed by Glover and the use of a structured branch-and-cut (B&C) solver to harness the advantages of both methods. The suggested procedure was applied to a continuous flexible process network model and optimal solutions of small- to large-scale instances of the model were obtained in a relatively small number of iterations.

In the final chapter, Thijssen, Li and Mittendorff present an integrated approach for the optimal timing of developing new oil and gas fields. The overall framework is capable of identifying future bottlenecks in the network and evaluating options for removal of these bottlenecks. Several studies performed by the authors indicate that such an integrated network analysis helps to bring production closer to the technical potential of the wellhead platforms. It also provides significant insight into the impact that all changes together have on the performance of the network and the savings that can be achieved.

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.

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London, June 2007
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