Reading: Ch. 1. Introduction *(Managing the Supply Chain: The Definitive Guide for the Business Professional)*

Author: Simchi-Levi, David; Kaminsky, Philip; Simchi-Levi, Edith

Editor: N/A

Publisher: McGraw-Hill Publication Date: 2004 Pages: 1-18

Course: COMR_V 398 201 202 2024W2 Introduction to Business Processes and Operations
Course Code: 202 Term: 2024 Winter Term 2

Department: COMR_V

CHAPTER 1

Introduction

1.1 WHAT IS SUPPLY CHAIN MANAGEMENT?

Fierce competition in today's global markets, the introduction of products with shorter and shorter life cycles, and the heightened expectations of customers have forced business enterprises to invest in and focus attention on their supply chains. This, together with continuing advances in communications and transportation technologies (e.g., mobile communication, the Internet, and overnight delivery), has motivated the continuous evolution of the supply chain and of the techniques to manage it.

In a typical supply chain, raw materials are procured, and items are produced at one or more factories, shipped to warehouses for intermediate storage, and then shipped to retailers or customers. Consequently, to reduce cost and improve service levels, effective supply chain strategies must take into account the interactions at the various levels in the supply chain. The *supply chain*, which is also referred to as the *logistics network*, consists of suppliers, manufacturing centers, warehouses, distribution centers, and retail outlets, as well as raw materials, work-in-process inventory, and finished products that flow between the facilities (Fig. 1-1).

In this book we present and explain concepts, insights, practical tools, and decision support systems important for the effective

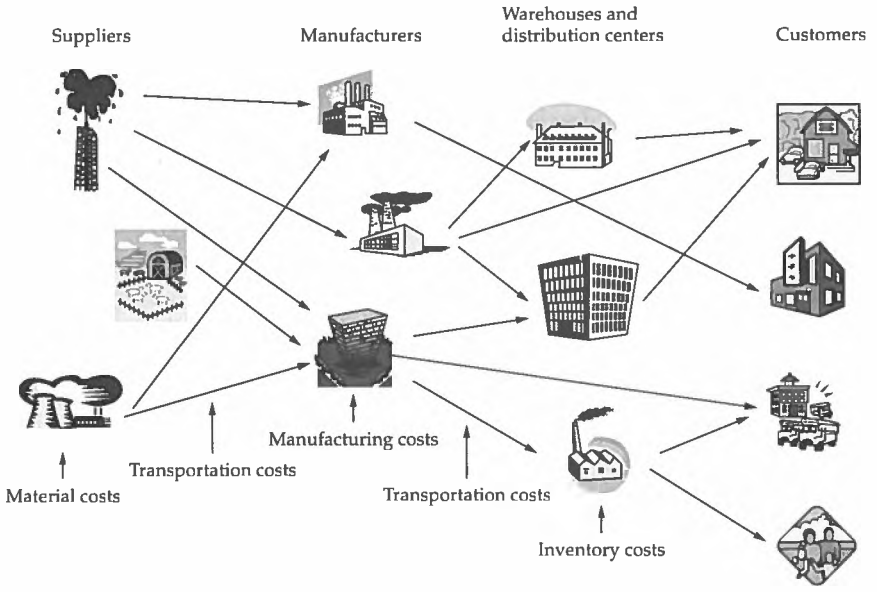

Figure 1-1 The logistics network.

management of the supply chain. But what exactly is *supply chain management?* We define it as follows:

> Supply chain management is a set of approaches used to efficiently integrate suppliers, manufacturers, warehouses, and stores so that merchandise is produced and distributed at the right quantities, to the right locations, and at the right time in order to minimize systemwide costs while satisfying service-level requirements.

This definition leads to several observations. First, supply chain management takes into consideration every facility that has an impact on cost and plays a role in making the product conform to customer requirements: from supplier and manufacturing facilities through warehouses and distribution centers to retailers and stores. Indeed, in some supply chain analysis, it is necessary to account for the suppliers' suppliers and the customers' customers because they have an impact on supply chain performance. Second, the objective of supply chain management is to be efficient and cost-effective across the entire system; total systemwide costs, from transportation and distribution to

inventories of raw materials, work in process, and finished goods, are to be minimized. Thus the emphasis is not on simply minimizing transportation cost or reducing inventories but rather on taking a *systems approach* to supply chain management. Finally, because supply chain management revolves around efficient integration of suppliers, manufacturers, warehouses, and stores, it encompasses the firm's activities at many levels, from the strategic level through the tactical to the operational level.

What about logistics management? What is the difference between supply chain management and logistics management? While the answer to this question depends on who is addressing this issue, we will not distinguish between logistics and supply chain management in this text. Indeed, our definition of supply chain management is similar to the definition of *logistics management* given by the Council of Logistics Management:

> The process of planning, implementing, and controlling the efficient, cost-effective flow and storage of raw materials, in-process inventory, finished goods, and related information from point of origin to point of consumption for the purpose of conforming to customer requirements.

What makes supply chain management difficult? Although we will discuss a variety of reasons throughout this text, they can all be related to one or both of the following observations:

1. It is challenging to design and operate a supply chain so that total systemwide costs are minimized and systemwide service levels are maintained. Indeed, it is frequently difficult to operate *a single facility* so that costs are minimized and service level is maintained. The difficulty increases exponentially when an entire system is being considered. The process of finding the best *systemwide* strategy is known as *global optimization.*
2. Uncertainty is inherent in every supply chain; customer demand can never be forecast exactly, travel times will never be certain, and machines and vehicles will break down. Supply chains need to be designed to eliminate as much uncertainty as possible and to deal effectively with the uncertainty that remains.

In the next two sections we discuss each of these issues in detail.

1.2 GLOBAL OPTIMIZATION

What makes finding the best systemwide, or globally optimal, integrated solution so difficult? A number of factors make this a challenging problem:

1. The supply chain is a complex network of facilities dispersed over a large geography and, in many cases, all over the globe. The following example illustrates a network that is fairly typical of today's global companies.

EXAMPLE 1-1

National Semiconductor, whose list of competitors includes Motorola, Inc., and the Intel Corporation, is one of the world's largest chipmakers whose products are used in fax machines, cellular phones, computers, and cars. Currently, the company has four wafer fabrication facilities, three in the United States and one in Great Britain, and has test and assembly sites in Malaysia and Singapore. After assembly, finished products are shipped to hundreds of manufacturing facilities all over the world, including those of Compaq, Ford, IBM, and Siemens. Since the semiconductor industry is highly competitive, specifying short lead times and being able to deliver within the committed due date are critical capabilities. In 1994, 95 percent of National Semiconductor's customers received their orders within 45 days from the time the order was placed, whereas the remaining 5 percent received their orders within 90 days. These tight lead times required the company to involve 12 different airline carriers using about 20,000 different routes. The difficulty, of course, was that no customer knew in advance if they were going to be part of the 5 percent of customers who received their order in 90 days or the 95 percent who received their order within 45 days.[1]

2. Different facilities in the supply chain frequently have *different, conflicting objectives.* For instance, suppliers typically want manufacturers to commit themselves to purchasing large quantities in stable volumes with flexible delivery dates. Unfortunately, although most manufacturers would like to implement long production runs, they need to be flexible to their customers' needs and changing demands. Thus the suppliers' goals are in direct conflict with the manufacturers' desire for flexibility. Indeed, since production decisions typically are made without precise information about customer demand, the ability

of manufacturers to match supply and demand depends largely on their ability to change supply volume as information about demand arrives. Similarly, the manufacturers' objective of making large production batches typically conflicts with the objective of both warehouses and distribution centers to reduce inventory. To make matters worse, this latter objective of reducing inventory levels typically implies an increase in transportation costs.

3. The supply chain is a dynamic system that evolves over time. Indeed, not only do customer demand and supplier capabilities change over time, but supply chain relationships also evolve over time. For example, as customers' power increases, there is increased pressure placed on manufacturers and suppliers to produce an enormous variety of high-quality products and, ultimately, to produce customized products.

4. System variations over time are also an important consideration. Even when demand is known precisely (e.g., because of contractual agreements), the planning process needs to account for demand and cost parameters varying over time due to the impact of seasonal fluctuations, trends, advertising and promotions, competitors' pricing strategies, and so forth. These time-varying demand and cost parameters make it difficult to determine the most effective supply chain strategy, i.e., the one that minimizes systemwide costs and conforms to customer requirements.

1.3 MANAGING UNCERTAINTY

Global optimization is made even more difficult because supply chains need to be designed for and operated in uncertain environments. A number of factors contribute to this:

1. Matching supply and demand is a major challenge:
   a. Boeing Aircraft announced a write-down of $2.6 billion in October 1997 due to "raw material shortages, internal and supplier parts shortages and productivity inefficiencies. . . ."[2]
   b. "Second quarter sales at U.S. Surgical Corporation declined 25 percent, resulting in a loss of $22 million. The sales and earnings shortfall is attributed to larger than anticipated inventories on the shelves of hospitals."[3]
   c. "IBM sells out New Aptiva PC; shortage may cost millions in potential revenue."[4]

Obviously, this difficulty stems from the fact that months before demand is realized, manufacturers have to commit themselves to specific production levels. These advance commitments imply huge financial and supply risks.

2. Inventory and back-order levels fluctuate considerably across the supply chain, even when customer demand for specific products does not vary greatly. To illustrate this issue, consider Figure 1-2, which suggests that in a typical supply chain, distributor orders to the factory fluctuate far more than the underlying retailer demand.
3. Forecasting does not solve the problem. Indeed, we argue in the first principle of all forecasts (see Chap. 2) that "forecasts are always wrong." Thus it is impossible to predict the precise demand for a specific item, even with the most advanced forecast techniques.
4. Demand is not the only source of uncertainty. Delivery lead times, manufacturing yields, transportation times, and component availability also can have significant supply chain

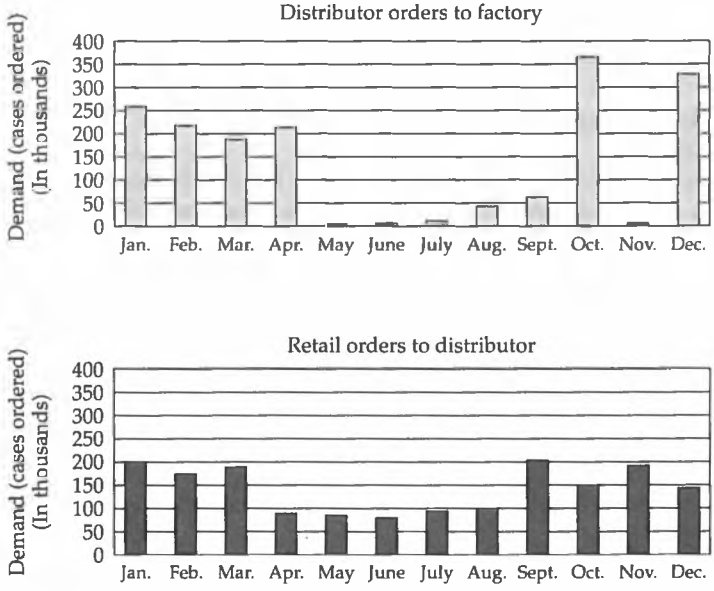

Figure 1-2 Order variations in the supply chain.

impact. As supply chains become larger and more geographically diverse, natural and human-made disasters can have tremendous impact.

EXAMPLE 1-2

In September 1999, a massive earthquake devastated Taiwan. Initially, 80 percent of the island's power was lost. Companies such as Hewlett-Packard and Dell, who source a variety of components from Taiwanese manufacturers, were affected by supply interruptions.[5] Similarly, fabric shipments from India were delayed in the wake of the January 26, 2001 earthquake in the Indian state of Gujarat, affecting many U.S. apparel manufacturers.[6]

Although uncertainty cannot be eliminated, we will explore various approaches that *minimize the effect* of uncertainty in the supply chain. When this is not possible, we will identify strategies that supply chain partners can apply so as to maintain or increase service level.

1.4 WHY SUPPLY CHAIN MANAGEMENT?

In the 1980s, companies discovered new manufacturing technologies and strategies that allowed them to reduce costs and better compete in different markets. Strategies such as just-in-time manufacturing, *kanban*, lean manufacturing, total quality management, and others became very popular, and vast quantities of resources were invested in implementing these strategies. In the last few years, however, it has become clear that many companies have reduced manufacturing costs as much as is practically possible. Many of these companies are discovering that effective supply chain management is the next step they need to take to increase profit and market share.

Indeed, in 1998 American companies spent $898 billion, or about 10 percent of the U.S. gross national product (GNP), on supply-related activities. During 2000, this cost increased to over $1 trillion, decreasing to $957 billion in 2001 and $910 billion in 2002.[7] This figure includes the cost of movement, storage, and control of products across the supply chain both within manufacturing plants and warehouses and between different components of the supply chain. Unfortunately, this huge investment typically includes many unnecessary

cost components due to redundant stock, inefficient transportation strategies, and other wasteful practices in the supply chain. For instance, experts believe that the grocery industry can save about $30 billion, or 10 percent of its annual operating cost, by using more effective supply chain strategies.[1]

To illustrate this issue, consider the following two examples:

1. It takes a typical box of cereal more than 3 months to get from the factory to a supermarket.
2. It takes a typical new car, on average, 15 days to travel from the factory to the dealership. This lead time should be compared with the actual travel time, which is no more than 4 to 5 days.

Thus many opportunities exist to cut costs in the supply chain. Not surprisingly, a number of companies have been able to substantially increase revenue or decrease costs through effective supply chain management.

EXAMPLE 1-3

Procter & Gamble estimates that it saved retail customers $65 million in a recent 18-month supply chain initiative. "According to Procter & Gamble, the essence of its approach lies in manufacturers and suppliers working closely together . . . jointly creating business plans to eliminate the source of wasteful practices across the entire supply chain."[8]

This example suggests that *strategic partnerships* between suppliers and manufacturers may have a significant impact on supply chain performance. What are the types of *business plans* and *partnerships* that can best reduce costs and improve service levels? Which one is appropriate for the particular situation at hand? What incentives and performance measures should be used to make the partnership successful? Finally, how should the benefits resulting from the strategic partnerships be shared? Should the cost savings be transferred to the customers, split between the different partners, or kept by the most powerful player?

EXAMPLE 1-4

In 2 years, National Semiconductor reduced distribution costs by 2.5 percent, decreased delivery time by 47 percent, and increased sales by 34 percent by closing six warehouses around the globe and air-freighting microchips to customers from a new centralized distribution center in Singapore.[1]

Of course, by switching to air carriers, National Semiconductor increased transportation costs significantly. This increase was offset by a reduction in inventory costs resulting from the shift from a decentralized distribution system with a number of warehouses to a centralized system with a single warehouse. This example motivates the following question: What are the correct tradeoffs between inventory and transportation costs?

EXAMPLE 1-5

Nabisco, Inc., delivers 500 types of cookies and more than 10,000 candies to over 80,000 buyers and spends more than $200 million a year in transportation expenses. Unfortunately, too many trucks arrive at or depart from their destinations half empty. This is why Nabisco is pioneering a collaborative logistics effort so that it can share trucks and warehouse space with other companies in order to lower logistics costs. In a recent pilot program, Nabisco shared warehouses and trucks with 25 other manufacturers, including Dole and Lea & Perrins. In one test involving 8000 orders, grocer Lucky Stores reduced inventory costs by $4.8 million. Nabisco itself saved $78,000 in shipping costs, and combined, all the manufacturers involved in the test saved nearly $900,000.[9]

Of course, this type of cooperation with other companies requires advanced information systems and entails a number of risks. What systems are necessary for this approach to be a success? When should a company undertake this type of complicated partnership?

EXAMPLE 1-6

Dayton Hudson Corporation's Target stores rely on sophisticated relationships with suppliers. Target, for example, may agree that an

(*continued*)

earthenware manufacturer will supply a certain number of Italian bowls without specifying details of style and color. As the delivery date draws nearer, Target forecasts styles that are likely to sell. Based on these forecasts, the manufacturer can produce trial lots, which can be sold in select Target stores to determine if the particular styles manufactured will indeed sell.[10]

Clearly, this level of flexibility increases the complexity of the supplier's supply chain. Why would the supplier agree to this type of arrangement? How much does Target gain with this type of flexible ordering? Should Target be willing to pay more per bowl for this flexibility? If so, how much more? And finally, what type of information system needs to be employed by Target and its suppliers to support this level of flexibility?

EXAMPLE 1-7

In 1979, Kmart was one of the leading companies in the retail industry, with 1891 stores and average revenues per store of $7.25 million. At that time, Wal-Mart was a small niche retailer in the South with only 229 stores and average revenues about half those of Kmart stores. In 10 years, Wal-Mart had transformed itself; in 1992 it had the highest sales per square foot and the highest inventory turnover and operating profit of any discount retailer.[11] Today Wal-Mart is the largest and highest-profit retailer in the world. In fact, sales for year ending Jan. 2003 were $244.5 billion, and it is also the largest employer in the US. How did Wal-Mart do it? The starting point was a relentless focus on satisfying customer needs; Wal-Mart's goal was simply to provide customers with access to goods when and where they want them and to develop cost structures that enable competitive pricing. The key to achieving this goal was to make the way the company replenishes inventory the centerpiece of its strategy. This was done by using a logistics technique known as *cross-docking*. In this strategy, goods are continuously delivered to Wal-Mart's warehouses, from where they are dispatched to stores without ever sitting in inventory. This strategy reduced Wal-Mart's cost of sales significantly and made it possible to offer everyday low prices to their customers.[12]

If the cross-docking strategy works so well for Wal-Mart, shouldn't all companies use the same strategy? Indeed, many success-

ful retailers employ other distribution strategies; some keep inventory at their warehouses, whereas others ship directly to stores.

EXAMPLE 1-8

The Home Depot, Inc., moves over 85 percent of its merchandise directly from suppliers to stores, avoiding warehouses altogether. In addition, since such a high volume of goods moves through its stores ($44 million in annual sales on average), the products frequently are shipped in full truck loads, for additional savings.[10]

These examples describe a number of supply chain management success st They suggest that in some industries, supply chain management is perhaps the single most important factor determining the success of the firm. Indeed, in the computer and printer industries, where most manufacturers use the same suppliers and identical technologies, companies compete on cost and service levels, the two key elements in our definition of supply chain management.

The examples also raise an important question. If these firms have improved supply chain performance by focusing on strategic partnering, using centralized warehousing, or employing the cross-docking strategy, what inhibits other firms from adopting the same techniques to improve their supply chain performance?

The earlier discussion suggests that the answer involves two major issues:

- The ability to replace traditional supply chain strategies, in which each facility or party in the chain makes decisions with little regard to their impact on other supply chain partners, by those which yield a *globally optimized* supply chain.
- The ability to effectively manage uncertainty. Unfortunately, the level of demand uncertainty has increased in the last few years. Indeed, in high-tech industries, product life cycles are becoming shorter and shorter. In particular, many computer and printer models have life cycles of only a few months, so the manufacturer may have only one order or production opportunity. Unfortunately, since these are new products, no historical data are available that allow the manufacturer to accurately predict customer demand. At the same time, the proliferation of products in these industries makes it

increasingly difficult to predict demand for a specific model. Finally, significant price declines in these industries are common, reducing the product value during its life cycle.[13]

EXAMPLE 1-9

A Korean manufacturer of electrical products such as industrial relays is facing a service level of about 70 percent; i.e., only about 70 percent of all orders are delivered on time. On the other hand, inventory keeps piling up, mostly of products that are not in demand. The manufacturer's *inventory turnover ratio*, defined as the ratio of the annual flow to average inventory at the manufacturer's main warehouse, is about four. However, in the electronics industry, leading companies turn inventory over about nine times a year. If the Korean manufacturer can increase its inventory turns to this level, it will be able to significantly reduce inventory levels. The manufacturer is thus searching for new strategies that will increase service levels over the next 3 years to about 99 percent and, at the same time, significantly decrease inventory levels and cost.

Just a few years ago, most analysts would have said that the two objectives described in Example 1-9, improved service and inventory levels, could not be achieved at the same time. Indeed, traditional inventory theory tells us that to increase service level, the firm must increase inventory and therefore cost. Surprisingly, recent developments in information and communications technologies, together with a better understanding of supply chain strategies, have led to innovative approaches that allow the firm to improve both objectives simultaneously.

Throughout the rest of this book we endeavor to present these approaches and strategies in detail. We will focus on demonstrating why certain strategies are adopted, what the tradeoffs are between different strategies, and how specific strategies are implemented in practice.

1.5 KEY ISSUES IN SUPPLY CHAIN MANAGEMENT

In this section we introduce some of the supply chain management issues that we discuss in much more detail throughout the remaining

chapters. These issues span a large spectrum of a firm's activities, from the strategic through the tactical to the operational level:

- The *strategic level* deals with decisions that have a long-lasting effect on the firm. These include decisions regarding the number, location, and capacity of warehouses and manufacturing plants and the flow of material through the logistics network.
- The *tactical level* includes decisions that are typically updated anywhere between once every quarter and once every year. These include purchasing and production decisions, inventory policies, and transportation strategies, including the frequency with which customers are visited.
- The *operational level* refers to day-to-day decisions such as scheduling, lead time quotations, routing, and truck loading.

Below we introduce and discuss some of the key issues, questions, and tradeoffs associated with different decisions.

Network Planning Consider several plants producing products to serve a set of geographically dispersed retailers. The current set of warehouses is deemed inappropriate, and management wants to reorganize or redesign the distribution network. This may be due, for example, to changing demand patterns or the termination of a leasing contract for a number of existing warehouses. In addition, changing demand patterns may require a change in plant production levels, a selection of new suppliers, and a new flow pattern of goods throughout the distribution network. How should management select a set of warehouse locations and capacities, determine production levels for each product at each plant, and set transportation flows between facilities, either from plant to warehouse or warehouse to retailer, in such a way as to minimize total production, inventory, and transportation costs and satisfy service level requirements? This is a complex optimization problem, and advanced technology and approaches are required to find a solution.

Inventory Control Consider a retailer that maintains an inventory of a particular product. Since customer demand changes over time, the retailer can use only historical data to predict demand. How should the

retailer manage inventory? More fundamentally, why should the retailer hold inventory in the first place? Is it due to uncertainty in customer demand, uncertainty in the supply process, or some other reasons? If it is due to uncertainty in customer demand, is there anything that can be done to reduce it?

Supply Contracts In traditional supply chain strategies, each party in the chain focuses on its own profit and hence makes decisions with little regard to their impact on other supply chain partners. Relationships between suppliers and buyers are established by means of supply contracts that specify pricing and volume discounts, delivery lead times, quality, returns, and so forth. The question, of course, is whether supply contracts also can be used to replace the traditional supply chain strategy with one that optimizes the entire supply chain performance? In particular, what is the impact of volume discount and revenue-sharing contracts on supply chain performance? Are there pricing strategies that can be applied by suppliers to provide incentives to buyers to order more products while at the same time increasing the supplier profit?

Distribution Strategies Wal-Mart's success story highlights the importance of a particular distribution strategy referred to as *cross-docking*. As observed earlier, this is a distribution strategy in which the stores are supplied by central warehouses that act as coordinators of the supply process and as transshipment points for incoming orders from outside vendors but that do not keep stock themselves. We refer to such warehouses as *cross-dock points*. Consider the following questions: How many cross-dock points are necessary? What are the savings achieved using a cross-docking strategy? How should a cross-docking strategy; be implemented in practice? Is the cross-docking strategy better than the classic strategy in which warehouses hold inventory? Which strategy should a particular firm employ: the cross-docking strategy; the classic distribution strategy in which inventory is kept at the warehouses; or direct shipping, a strategy in which items are shipped from suppliers directly to stores?

Supply Chain Integration and Strategic Partnering As observed earlier, designing and implementing a globally optimal supply chain are quite difficult because of the dynamics of the supply chain and the conflict-

ing objectives employed by different facilities and partners. Nevertheless, the National Semiconductor, Wal-Mart, and Procter & Gamble success stories demonstrate not only that an integrated, globally optimal supply chain is possible but also that it can have a huge impact on the company's performance and market share. Of course, one can argue that these three examples are associated with companies that are among the biggest companies in their respective industries; these companies can implement technologies and strategies that very few others can afford. However, in today's competitive markets, most companies have no choice; they are forced to integrate their supply chain and engage in strategic partnering. This pressure stems from both their customers and their supply chain partners. How can integration be achieved successfully? Clearly, information sharing and operational planning are the keys to a successfully integrated supply chain. But what information should be shared? How should it be used? How does information affect the design and operation of the supply chain? What level of integration is needed within the organization and with external partners? Finally, what types of partnerships can be implemented, and which type should be implemented for a given situation?

Outsourcing and Procurement Strategies Rethinking your supply chain strategy involves not only coordinating the different activities in the supply chain but also deciding what to make internally and what to buy from outside sources. How can a firm identify what manufacturing activities lie in its set of core competencies and thus should be completed internally and what products and components should be purchased from outside suppliers because these manufacturing activities are not core competencies? Is there any relationship between the answer to this question and product architecture? What are the risks associated with outsourcing, and how can these risks be minimized? When you do outsource, how can you ensure a timely supply of products? Finally, what is the impact of the Internet on procurement strategies? Should the firm use a private or public exchange when dealing with trading partners?

Product Design Effective design plays several critical roles in the supply chain. Most obviously, certain product designs may increase inventory holding or transportation costs relative to other designs,

whereas other designs may facilitate a shorter manufacturing lead time. Unfortunately, product redesign is often expensive. When is it worthwhile to redesign products so as to reduce logistics costs or supply chain lead times? Is it possible to leverage product design to compensate for uncertainty in customer demand? Can one quantify the amount of savings resulting from such a strategy? What changes should be made in the supply chain to take advantage of the new product design? Finally, new concepts such as mass customization are increasingly popular. What role does supply chain management play in the successful implementation of these concepts?

Customer Value Customer value is the measure of a company's contribution to its customer, based on the entire range of products, services, and intangibles that constitute the company's offerings. In recent years, this measure has superseded measures such as quality and customer satisfaction. Obviously, effective supply chain management is critical if a firm wishes to fulfill customer needs and provide value. But what determines customer value in different industries? How is customer value measured? How is information technology used to enhance customer value in the supply chain? How does supply chain management contribute to customer value? How do emerging trends in customer value, such as development of relationships and experiences, affect supply chain management? What is the relationship between product price and brand name in the conventional world and in the online world? Can "smart" pricing strategies be used to improve supply chain performance?

Information Technology and Decision-Support Systems Information technology is a critical enabler of effective supply chain management. Indeed, much of the current interest in supply chain management is motivated by the opportunities that appeared due to the abundance of data and the savings that can be achieved by sophisticated analysis of these data. The primary issue in supply chain management is not whether data can be received, but what data should be transferred; i.e., which data are significant for supply chain management and which data can be ignored safely? How should the data be analyzed and used? What is the impact of the Internet? What infrastructure is required both internally and between supply chain partners? Finally, since information technology and decision-support systems are both available,

Table 1-1 Key Supply-Chain Management Issues

	Global Optimization	Managing Uncertainty
Network planning	x	
Inventory control		x
Supply contracts	x	
Distribution strategies	x	x
Strategic partnerships	x	
Outsourcing and procurement		x
Product design		x
Customer value	x	x
Information technology	x	x

can these technologies be viewed as the main tools used to achieve competitive advantage in the market? If they can, then what is preventing others from using the same technology?

Each of these issues and strategies is discussed in great detail in the remaining chapters. As you will see, the focus in each case is on either achieving a *globally optimized* supply chain or managing uncertainty in the supply chain or both. A summary is provided in Table 1-1.

1.6 BOOK OBJECTIVES AND OVERVIEW

For many reasons, interest in logistics and supply chain management has grown explosively in the last few years. This interest has led many companies to analyze their supply chains. In most cases, however, this has been done based on experience and intuition; very few analytical models or design tools have been used in this process. Meanwhile, in the last two decades, the academic community has developed various models and tools to assist with management of the supply chain. Unfortunately, the first generation of this technology was not robust or flexible enough to be used effectively by industry. This, however, has changed in the last few years. Analysis and insight have improved, and effective models and decision-support systems have been developed—but these may not be familiar to industry.

This book aims to fill the gap by presenting state-of-the-art models and solution methods, insights, and concepts important in the

design, control, operation, and management of supply chain systems. Each chapter is mostly self-contained and includes numerous examples. We intend this book to be a reference for consultants and managers involved in any one of the processes that make up the supply chain. For example, transportation managers deciding which modes of transportation to use, inventory control managers wanting to ensure smooth production with as little inventory as possible, purchasing/supply managers designing contracts with their companies' suppliers and clients, and logistics managers in charge of their companies' supply chains can all benefit from the contents of this book.