Introduction to Supply Chain Management

1.1 WHAT IS SUPPLY CHAIN MANAGEMENT?

Fierce competition in today's global markets, the introduction of products with 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, Internet, and overnight delivery), has motivated the continuous evolution of the supply chain and of the techniques to manage it effectively.

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 (see Figure 1-1).

Figure 1-1

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

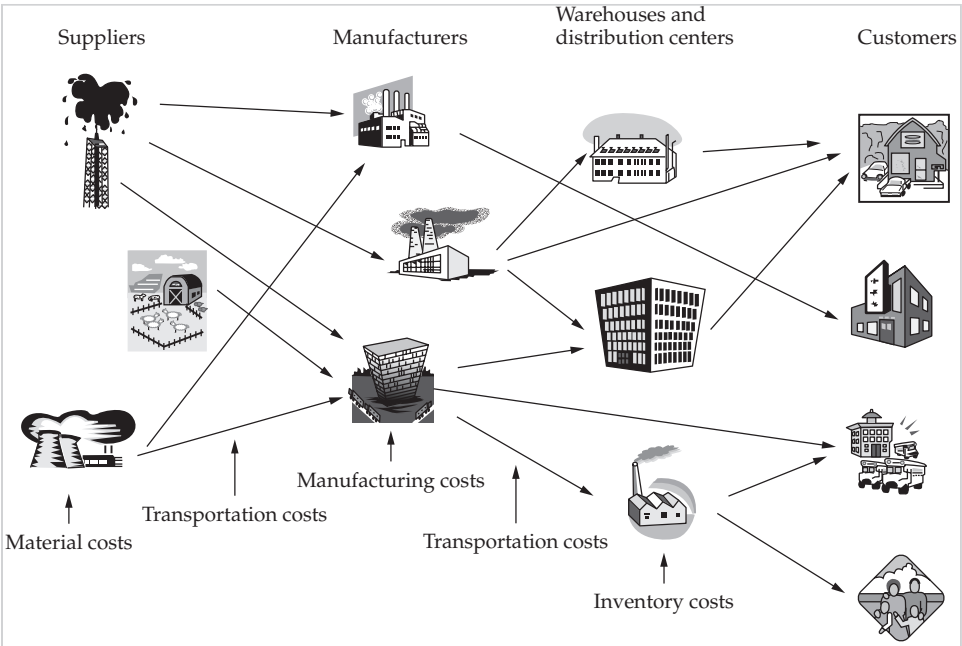

FIGURE 1-1 The logistics network.

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, or value chain management, or demand chain management? Various companies, consultants, and academics have developed a variety of terms and concepts to stress what they believe are the salient issues in supply chain management. Although many of these concepts are useful and insightful, for the purposes of this text, we will use supply chain management as the generic name for the set of concepts, approaches, strategies, and ideas that we are discussing.

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

1. **Supply chain strategies cannot be determined in isolation. They are directly affected by another chain that most organizations have, the *development chain*** that includes the set of activities associated with new product introduction. At the same time, supply chain strategies also should be aligned with the specific goals of the organization, such as maximizing market share or increasing profit.
2. **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*.

3. **Uncertainty and risk are 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. Similarly, recent industry trends, including outsourcing, offshoring, and lean manufacturing that focus on reducing supply chain costs, significantly increase the level of risk in the supply chain. Thus, supply chains need to be designed and managed to eliminate as much uncertainty and risk as possible as well as deal effectively with the uncertainty and risk that remain.

In the next three sections, we discuss these issues in more detail.

1.2 THE DEVELOPMENT CHAIN

The *development chain* is the set of activities and processes associated with new product introduction. It includes the product design phase, the associated capabilities and knowledge that need to be developed internally, sourcing decisions, and production plans. Specifically, the development chain includes decisions such as product architecture; what to make internally and what to buy from outside suppliers, that is, make/buy decisions; supplier selection; early supplier involvement; and strategic partnerships.

Figure 1-2

The development and supply chains intersect at the production point, as illustrated in Figure 1-2. It is clear that the characteristics of and decisions made in the development chain will have an impact on the supply chain. Similarly, it is intuitively clear that the characteristics of the supply chain must have an impact on product design strategy and hence on the development chain.

EXAMPLE 1-1

Hewlett Packard was one of the first firms to recognize the intersection of the development and supply chains. A case in point is the inkjet printer introduction, where decisions about product architecture were made by taking into account not only labor and material cost, but also total supply chain cost throughout the product life cycle. More recently, HP has focused on making decisions such as what design activities to outsource and the corresponding organizational structures needed to manage the outsource design process by considering the characteristics of both the development and the supply chains.

Unfortunately, in most organizations, different managers are responsible for the different activities that are part of these chains. Typically, the VP of engineering is responsible for the development chain, the VP of manufacturing for the production portion of the chains, and the VP of supply chain or logistics for the fulfillment of customer demand. Unless carefully addressed, the typical impact of this organizational structure is a misalignment of product design and supply chain strategies.

To make matters worse, in many organizations, additional chains intersect with both the development and the supply chains. These may include the reverse logistics chain, that is, the chain associated with returns of products or components, as well as the spare-parts chain. In this book, we explore the various characteristics of each of these supply chains in order to better understand the impact of these on product and supply chain strategies. We illustrate how the consideration of these characteristics lead to the development of frameworks to assist in matching products with strategies.

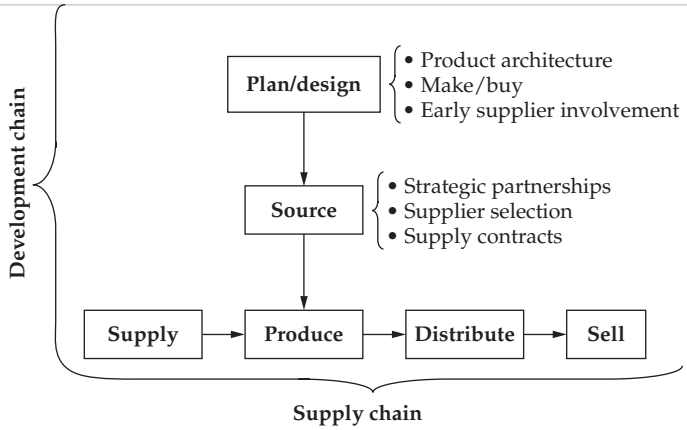

FIGURE 1-2 The enterprise development and supply chains.

1.3 GLOBAL OPTIMIZATION

What makes finding the best systemwide, or globally optimal, integrated solution so difficult? A variety 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 1-2

National Semiconductor, whose list of competitors includes Motorola Inc. and the Intel Corporation, is one of the world's largest manufacturers of analog devices and subsystems that are used in fax machines, cellular phones, computers, and cars. Currently, the company has four wafer fabrication facilities, two in the United States and one in Great Britain, and has test and assembly sites in Malaysia, China, and Singapore. After assembly, finished products are shipped to hundreds of manufacturing facilities all over the world, including those of Apple, Canon, Delphi, Ford, IBM, Hewlett-Packard, and Siemens. Since the semiconductor industry is highly competitive, short lead time specification and the ability 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, while 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 [69], [www.national.com].

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 are typically 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 objectives 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, the one that minimizes systemwide costs and conforms to customer requirements.

Of course, global optimization only implies that it is not only important to optimize across supply chain facilities, but also across processes associated with the development and supply chains. That is, it is important to identify processes and strategies that optimize, or, alternatively, synchronize, both chains simultaneously.

1.4 MANAGING UNCERTAINTY AND RISK

Global optimization is made even more difficult because supply chains need to be designed for, and operated in, uncertain environments, thus creating sometimes enormous risks to the organization. A variety 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 . . ." [161].
   - **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" [162].
   - **c.** "EMC Corp. said it missed its revenue guidance of $2.66 billion for the second quarter of 2006 by around $100 million, and said the discrepancy was due to higher than expected orders for the new DMX-3 systems over the DMX-2, which resulted in an inventory snafu" [C11].
   - **d.** "There are so many different ways inventory can enter our system it's a constant challenge to keep it under control" [Johnnie Dobbs, Wal-Mart Supply Chain and Logistics Executive].
   - **e.** "Intel, the world's largest chip maker, reported a 38 percent decline in quarterly profit Wednesday in the face of stiff competition from Advanced Micro Devices and a general slowdown in the personal computer market that caused inventories to swell" [C12].

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.

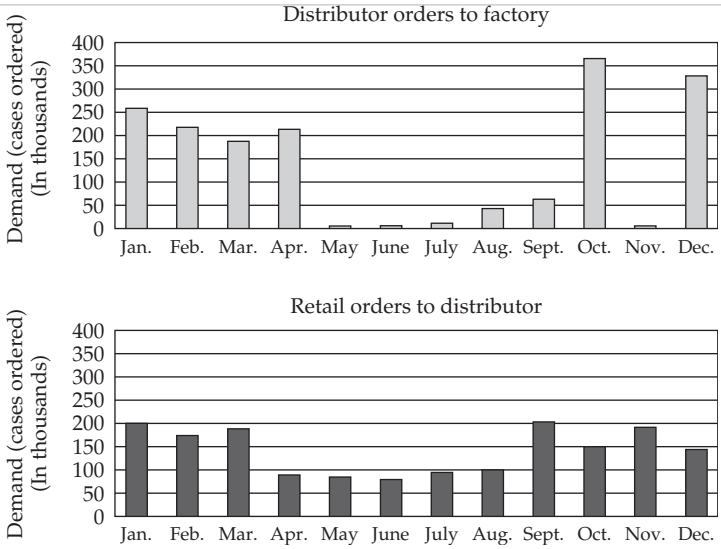

FIGURE 1-3 Order variations in the supply chain.

Figure 1-3

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 1-3, which suggests that in a typical supply chain, distributor orders to the factory fluctuate far more than the underlying retailer demand.
3. **Forecasting doesn't solve the problem.** Indeed, we will argue that the first principle of forecasting is that "forecasts are always wrong." Thus, it is impossible to predict the precise demand for a specific item, even with the most advanced forecasting 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 impact.
5. **Recent trends such as lean manufacturing, outsourcing, and offshoring that focus on cost reduction increase risks significantly.** For example, consider an automotive manufacturer whose parts suppliers are in Canada and Mexico. With little uncertainty in transportation and a stable supply schedule, parts can be delivered to assembly plants "just-in-time" based on fixed production schedules. However, in the event of an unforeseen disaster, such as the September 11 terrorist attacks, port strikes, or weather-related calamities, adherence to this type of strategy could result in a shutdown of the production lines due to lack of parts.

   Similarly, outsourcing and offshoring imply that the supply chains are more geographically diverse and, as a result, natural and man-made disasters can have a tremendous impact.

EXAMPLE 1-3

- On August 29, 2005, Hurricane Katrina devastated New Orleans and the Gulf coast. Proctor & Gamble coffee manufacturing, with brands such as Folgers that get over half of their supply from sites in New Orleans, was severely impacted by the hurricane. Six months later, there were, as a

EXAMPLE 1-3 ***Continued***

P&G executive told the *New York Times,* "still holes on the shelves" where P&G's brands should be [C13].

- A 2002 West Coast port strike shut down ports from Seattle to San Diego. Economists estimate that this strike cost the economy up to $1 billion a day, as stores could not be stocked, fruits and vegetables rotted, and factories were shut down due to lack of parts [C14].
- 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 impacted by supply interruptions [7].
- Fabric shipments from India were delayed in the wake of the January 26, 2001, earthquake in the Indian state of Gujarat, impacting many U.S. apparel manufacturers [49].

Although uncertainty and risk cannot be eliminated, we will explore a variety of examples that illustrate how product design, network modeling, information technology, procurement, and inventory strategies are used to minimize uncertainty, and to build flexibility and redundancy in the supply chain in order to reduce risks.

1.5 THE EVOLUTION OF 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 amounts 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 in order to increase profit and market share.

Indeed, logistics and supply chain costs play an important role in the U.S. economy: the annual "State of Logistics Report," which is sponsored by the Council of Supply Chain Management Professionals, first published in 1989, provides an accounting of the nation's total logistics bill and tracks trends in transportation costs, inventory-carrying costs, and total logistics costs. As you can see from Figure 1-4, U.S. logistics costs were over 12 percent of GDP in the early 80s, steadily decreasing until 2003. The absolute numbers are quite staggering: for 1998 the amount was

Figure 1-4

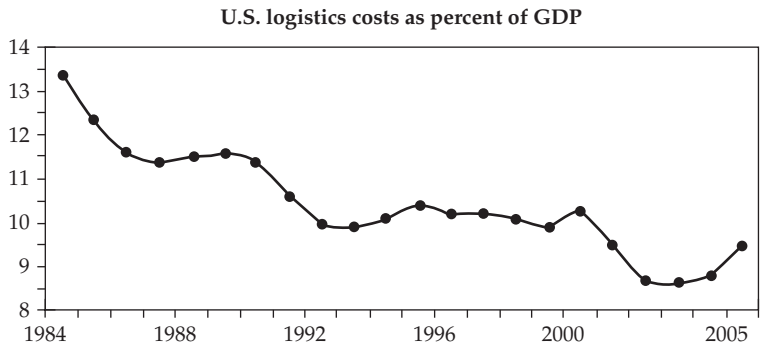

FIGURE 1-4 Logistics costs' share of the U.S. economy.
Source: Based on www.dcvelocity.com/articles/20060801/news.cfm.

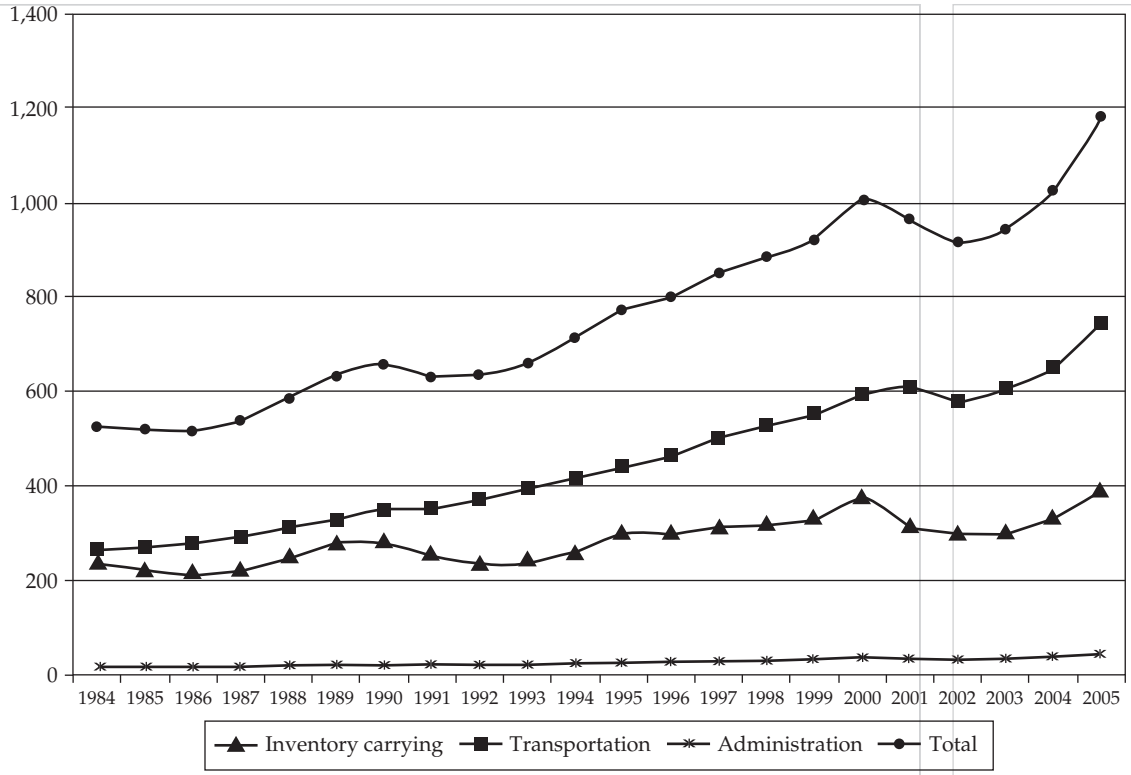

FIGURE 1-5 Total U.S. logistics costs between 1984 and 2005.
Source: Based on www.dcvelocity.com/articles/20060801/news.cfm.

$898 billion, while in 2005 it was $1.18 trillion. This $1.18 trillion represents an increase of $156 billion over 2004, which is even more striking if one considers that while the U.S. economy slowed down in 2005, logistics costs increased by about 15 percent. This increase was driven, according to the "State of Logistics Report," by "high fuel costs, truck driver and rail capacity shortages, offshoring and outsourcing and the costs of security."

Figure 1-5

It is also interesting to understand the magnitude of the various cost components that constitute the U.S. logistics costs. These data are presented in Figure 1-5 (taken again from the "State of Logistics Report"), where transportation cost is by far the largest cost component; inventory cost is slightly higher than half of the transportation costs. Both costs have steadily increased in the last few years, except that, until 2003, total logistics costs increased slower than the economy growth, while they have increased faster than the economy in the last two years.

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, a notoriously low-margin industry, can save about $30 billion, or 10 percent of its annual operating cost, by using more effective supply chain strategies [69]. To illustrate this issue, consider the following two examples:

1. It takes a typical box of cereal more than three 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 four to five days.

Thus, in the 1990s many companies focused on strategies to reduce their costs as well as those of their supply chain partners.

EXAMPLE 1-4

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" [160].

As the example suggests, an important building block in effective supply chain strategies is *strategic partnerships* between suppliers and buyers, partnerships that can help both parties reduce their costs.

Indeed, manufacturers such as Procter & Gamble and Kimberly-Clark and giant retailers like Wal-Mart have used strategic partnering as an important element in their business strategies. Firms such as 3M, Eastman Kodak, Dow Chemical, Time Warner, and General Motors turned over large portions of their logistics operations to third-party logistics providers.

At the same time, many supply chain partners engage in *information sharing* so that manufacturers are able to use retailers' up-to-date sales data to better predict demand and reduce lead times. This information sharing also allows manufacturers to control the variability in supply chains (known as the bullwhip effect, see Chapter 5), and by doing that reduce inventory and smooth out production.

EXAMPLE 1-5

Among the first companies to utilize real-time information was Milliken and Company, a textile and chemicals company. Milliken worked with several clothing suppliers and major department stores, all of which agreed to use POS data from the department stores to "synchronize" their ordering and manufacturing plans. The lead time from order receipt at Milliken's textile plants to final clothing receipt at the department stores was reduced from 18 weeks to 3 weeks [136].

The huge pressure during the 90s to reduce costs and increase profits pushed many industrial manufacturers towards *outsourcing;* firms considered outsourcing everything from the procurement function to production and manufacturing. Indeed, in the mid 90s there was a significant increase in purchasing volume as a percentage of the typical firm's total sales. More recently, between 1998 and 2000, outsourcing in the electronic industry has increased from 15 percent of all components to 40 percent [137].

Finally, in the late 90s, the *Internet* and the related *e-business models* led to expectations that many supply chain problems would be solved merely by using these new technologies and business models. E-business strategies were supposed to reduce cost, increase service level, and increase flexibility and, of course, increase profits, albeit sometime in the future. In reality, these expectations frequently were not met, as many e-businesses failed. In many cases, the downfall of some of the highest-profile Internet businesses can be attributed to their logistics strategies.

EXAMPLE 1-6

Furniture.com, launched in January 1999, offered thousands of products from many furniture makers, although only a few brand names. The company had $22 million in sales in the first nine months of 2000 and one million visitors a month to its Web site. Its downfall in November of 2000 was due to logistics details, and, in particular, inefficient delivery processes. Initially, Furniture.com used carriers to ship its products from a central warehouse to the customers. Since transportation costs were too high, the firm formed an alliance with six regional distributors. Unfortunately, these relationships were hard to maintain and left many problems unsolved, including handling of repairs and returns.

Of course, in many cases, the Internet introduced new channels and helped to enable the direct-to-consumer business model. These new channels required many companies to learn new skills, and added complexity to existing supply chains.

EXAMPLE 1-7

According to the Stern Stewart EVA 1000 database, Dell Computers outperformed the competition by over 3,000 percent in terms of shareholder growth over the eight-year period from 1988 to 1996. Dell's success over this period can be attributed to its virtual integration, a strategy that blurs the traditional boundaries between suppliers, manufacturers, and end users. Dell's decision to sell computers built from components produced by other manufacturers relieved the firm of the burdens of owning assets, doing research and development, and managing a large workforce. At the same time, the Dell model of direct sales to consumers and production to order virtually eliminated finished goods inventory. These business decisions allowed Dell to grow much faster than its competition and maintain only eight days of inventory.

The landscape has changed in recent years. Industry recognized that trends, including outsourcing, offshoring, lean manufacturing, and just-in-time, that focus on reducing manufacturing and supply chain costs significantly increase the level of risk in the supply chain. As a result, over the past several years, progressive firms have started to focus on strategies that find the right balance between cost reduction and risk management.

A number of approaches have been applied by industry to manage risk in their supply chains:

- Building redundancy into the supply chain so that if one portion fails, for example, a fire at a warehouse or a closed port, the supply chain can still satisfy demand.
- Using information to better sense and respond to disruptive events.
- Incorporating flexibility into supply contracts to better match supply and demand.
- Improving supply chain processes by including risk assessment measures.

Of course, many of these approaches rely heavily on technology. Indeed, the implementation of ERP systems, motivated in many companies by year 2000 concerns, as well as new technology such as tools for supplier performance assessments, have created opportunities to improve supply chain resiliency and responsiveness. Similarly, advanced inventory planning systems are now used to better position inventory in the supply chain, and to help firms better understand the impact of product design alternatives on supply chain costs and risks, thus facilitating the integration of the development chain and the supply chain.

EXAMPLE 1-8

United Technologies Corp. (UTC) continuously measures and evaluates suppliers' performance using third-party vendor software. The software not only relies on historical delivery data but also on external financial data on each supplier to create supplier risk alerts. UTC complements the

EXAMPLE 1-8 ***Continued***

supplier performance and risk alert system with teams that help tier 1 suppliers improve their supply chain and reduced risks with their own suppliers. According to UTC, these initiatives significantly increased inventory turns and reduced cost of nonquality (unplanned overtime, scrap, etc.) [C15].

As we saw in Figure 1-4, the urgency of supply chain challenges has not diminished over the years with the recent increase in supply chain costs. With complexity driven by globalization, high transportation costs, poor infrastructure, weather-related disasters, and terrorist threats, managing the supply chain has become even more challenging. Throughout this text, we demonstrate how new technology and supply chain strategies can help companies deal with these challenges.

1.6 THE COMPLEXITY

The preceding section describes a number of supply chain management success stories: Procter & Gamble, Wal-Mart, UTC, and others. 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 information sharing and technology, or by applying risk mitigation strategies, what inhibits other firms from adopting the same techniques to improve their supply chain performance?

The earlier discussion suggests that the answer involves three critical abilities that successful firms must possess:

- The ability to match supply chain strategies with product characteristics. Indeed, it is clear that the supply chain strategy for products and industries where the technology changes frequently, the so-called fast clock speed products, must be fundamentally different than that of slow clock speed products. Similarly, product design strategy not only depends on characteristics of the development chain not also on supply chain characteristics. Thus, the intersection of the development chain and the supply chain has an impact on both product design and supply chain strategy.
- 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 that yield a *globally optimized* supply chain.
- The ability to effectively manage uncertainty and risk. As observed earlier, initiatives such as outsourcing and offshoring and manufacturing strategies such as lean and just-in-time have significantly increased the level of risk for the enterprise. This is complemented by the significant increase in the level of demand uncertainty. 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 [112].

EXAMPLE 1-9

A Korean manufacturer of electrical products such as industrial relays is facing a service level of about 70 percent; that is, 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 three 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 these two objectives, 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 trade-offs are between different strategies, and how specific strategies are implemented in practice.

1.7 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. This includes decisions regarding product design, what to make internally and what to outsource, supplier selection, and strategic partnering as well as decisions on 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 trade-offs associated with different decisions.

Distribution Network Configuration 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. The retailer's objective is to decide at what point to reorder a new batch of the product, and how much to order so as to minimize inventory ordering and holding costs. 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? What is the impact of the forecasting tool used to predict customer demand? Should the retailer order more than, less than, or exactly the demand forecast? And, finally, what inventory turnover ratio should be used? Does it change from industry to industry?

Production Sourcing In many industries, there is a need to carefully balance transportation and manufacturing costs. In particular, reducing production costs typically implies that each manufacturing facility is responsible for a small set of products so that large batches are produced, hence reducing production costs. Unfortunately, this may lead to higher transportation costs.

Similarly, reducing transportation costs typically implies that each facility is flexible and has the ability to produce most or all products, but this leads to small batches and hence increases production costs. Finding the right balance between the two cost components is difficult but needs to be done monthly or quarterly.

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 for buyers to order more products while at the same time increasing the supplier profit?

Distribution Strategies An important challenge faced by many organizations is how much should they centralize (or decentralize) their distribution system. What is the impact of each strategy on inventory levels and transportation costs? What about the impact on service levels? And, finally, when should products be transported by air from centralized locations to the various demand points? These questions are not only important for a single firm determining its distribution strategy, but also for competing

retailers that need to decide how much they can collaborate with each other. For example, should competing dealers selling the same brand share inventory? If so, what is their competitive advantage?

Supply Chain Integration and Strategic Partnering As observed earlier, designing and implementing a globally optimal supply chain is quite difficult because of its dynamics and the conflicting objectives employed by different facilities and partners. Nevertheless, Dell, Wal-Mart, and Procter & Gamble success stories demonstrate not only that an integrated, globally optimal supply chain is possible, but 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 Offshoring Strategies Rethinking your supply chain strategy not only involves 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 product and components should be purchased from outside suppliers, because these manufacturing activities are not core competencies? Is there any relationship between the answer to that 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? And when should the firm keep dual sources for the same component? Finally, even if the firm decides not to outsource activities, when does it make sense to move facilities to the Far East? What is the impact of offshoring on inventory levels and the cost of capital? What are the risks?

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, while 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?

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; that is, which data are significant for supply chain management and which data can safely be ignored? How frequently should data be transferred and analyzed? What is the impact of the Internet? What is the role of electronic commerce? What infrastructure is required both internally and between supply chain partners? Finally, since information technology and decision-support systems are both available, 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?

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?

Smart Pricing Revenue management strategies have been applied successfully in industries such as airlines, hotels, and rental cars. In recent years, a number of manufactures, retailers, and carriers have applied a variation of these techniques to improve supply chain performance. In this case, the firm integrates pricing and inventory (or available capacity) to influence market demand and improve the bottom line. How is this done? Can "smart" pricing strategies be used to improve supply chain performance? What is the impact of rebate strategies on the supply chain?

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 the development chain or the supply chain and the focus is on achieving a *globally optimized* supply chain or managing risk and uncertainty in the supply chain, or both. A summary is provided in Table 1-1.

Table 1-1

TABLE 1-1

KEY SUPPLY CHAIN MANAGEMENT ISSUES

	Chain	Global optimization	Managing risk and uncertainty
Distribution network configuration	Supply	Y	
Inventory control	Supply		Y
Production sourcing	Supply	Y	
Supply contracts	Both	Y	Y
Distribution strategies	Supply	Y	Y
Strategic partnering	Development	Y	
Outsourcing and offshoring	Development	Y	
Product design	Development		Y
Information technology	Supply	Y	Y
Customer value	Both	Y	Y
Smart pricing	Supply	Y	

1.8 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 the management of the supply chain. Unfortunately, the first generation of this technology was not robust or flexible enough to be effectively utilized 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 fills this gap by presenting state-of-the-art models and solution methods important in the design, control, operation, and management of supply chain systems. We intend this book to be useful both as a textbook for MBA-level logistics and supply chain courses and as a reference for teachers, consultants, and managers involved in any one of the processes that make up the supply chain. Each chapter includes case studies, numerous examples, and discussion questions. In addition, each chapter is mostly self-contained, and mathematical and technical sections can be skipped without loss of continuity. Therefore, we believe the book is accessible to anyone with an interest in some of the many aspects of supply chain management. 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 company's suppliers and clients, and logistics managers in charge of their company's supply chains all can benefit from the contents of this book.

The book includes chapters covering the following topics:

- Inventory management.
- Logistics network planning.
- Supply contracts for strategic as well as commodity components.
- The value of information and the effective use of information in the supply chain.
- Supply chain integration.
- Centralized and decentralized distribution strategies.
- Strategic alliances.
- Outsourcing, offshoring, and procurement strategies.
- International logistics and risk management strategies.
- Supply chain management and product design.
- Customer value.
- Revenue management and pricing strategies.
- Information technology and business processes.
- Technical standards and their impact on the supply chain.

In addition, three software packages, the **Computerized Beer Game,** the **Risk Pool Game,** and the **Procurement Game,** as well as a set of spreadsheets, are included with the book. The Computerized Beer Game is an advanced version of a traditional supply chain management role-playing simulation, first developed at MIT. In addition to replicating the traditional board-based game, the Computerized Beer Game has many options and features that enable the reader to explore a variety of simple and advanced supply chain management concepts that cannot be easily taught using the traditional

game. This includes the value of information sharing, the impact of long and short lead times, and the difference between centralized and decentralized decision making on supply chain performance. This game complements much of what we discuss in the text; in particular, it helps to clarify many of the points raised in Chapter 5.

Similarly, the Risk Pool Game was developed to illustrate important issues in inventory management and, in particular, an important concept in supply chain management referred to as *risk pooling,* a concept that we discuss in Chapter 2. In the game, the player simultaneously manages both a supply chain with a single warehouse and a supply chain without any warehouse. In the latter case, the player delivers finished goods directly from the suppliers to the retail outlets. Throughout the game, the software records the profits of both supply chains, so that the player can compare the performance of the centralized and decentralized systems.

The Procurement Game was developed to illustrate the impact of flexible (option) contracts and supplier competition on the behavior of both the suppliers and the buyer. The game presents a realistic situation in the high-tech industry where demand uncertainty is high and buyers need to reserve capacity in advance of the selling season with one or more suppliers. The game complements the material on procurement strategies in Chapter 9. The three software packages are described in detail in the appendix.

Finally, a series of spreadsheets is included with the book. These spreadsheets illustrate the various inventory concepts and *supply contracts* described in Chapters 2 and 4.

DISCUSSION QUESTIONS

1. Consider the supply chain for a domestic automobile.
   - **a.** What are the components of the supply chain for the automobile?
   - **b.** What are the different firms involved in the supply chain?
   - **c.** What are the objectives of these firms?
   - **d.** Provide examples of conflicting objectives in this supply chain.
   - **e.** What are the risks that rare or unexpected events pose to this supply chain?
2. Consider a consumer mortgage offered by a bank.
   - **a.** What are the components of the supply chain for the mortgage?
   - **b.** Is there more than one firm involved in the supply chain? What are the objectives of the firm or firms?
   - **c.** What are the similarities between product and service supply chains? What are the differences?
3. What is an example of a supply chain that has evolved over time?
4. A vertically integrated company is a company that owns, manages, and operates all its business functions. A horizontally integrated company is a corporation consisting of a number of companies, each of which is acting independently. The corporation provides branding, direction, and general strategy. Compare and contrast the supply chain strategies of the two types of companies.
5. If a firm is completely vertically integrated, is effective supply chain management still important?
6. Consider the supply chain for canned peaches sold by a major food processing company. What are the sources of uncertainty in this supply chain?
7. Consider a firm redesigning its logistics network. What are the advantages to having a small number of centrally located warehouses? What are the advantages to having a larger number of warehouses closer to the end customers?

8. Consider a firm selecting a supplier of transportation services? What are the advantages to using a truckload carrier? A package delivery firm such as UPS?
9. What are the advantages to a firm of high inventory levels? What are the disadvantages? What are the advantages of low inventory levels? The disadvantages?
10. What are some ways that redundancy can be built into a supply chain? What are the advantages and disadvantages of building redundancy into the supply chain?
11. Consider Figure 1-5. What are the reasons for the increase in transportation costs? Inventory costs? Does one affect the other? How?

Meditech Surgical

Three years after Meditech was spun off from its parent company, Meditech captured a majority of the endoscopic surgical instrument market. Its primary competitor, National Medical Corporation, had practically invented the $800 million market just over a decade ago. But Meditech competed aggressively, developing new, innovative instruments and selling them through a first-class sales force. The combination paid off, and Meditech had become a phenomenal success in a short period of time. Despite the success, Dan Franklin, manager of Customer Service and Distribution, was concerned about growing customer dissatisfaction. Meditech had recently introduced several new products that were central to the entire Meditech product line. New product introductions, which were critical to Meditech's strategy of rapid product development, needed to be introduced flawlessly to protect Meditech's reputation and sales of other products. But Meditech consistently failed to keep up with demand during the flood of initial orders. Production capacity became strained as customers waited over six weeks to have their orders delivered. Poor delivery service, which is fatal in the health care industry, was jeopardizing Meditech's reputation.

COMPANY BACKGROUND

Endoscopic surgical techniques fall under a class of surgical procedures described as minimally invasive. Minimally invasive surgery, as opposed to traditional open surgery, requires only small incisions to perform an operation. As a result, procedures using endoscopic techniques often provide substantial benefits for the patient both physically and financially. The procedures often shorten patient recovery, which can translate into reduced surgical expenses overall. Despite the benefits and the multidecade history of endoscopic technology, the procedures have only become popular in the last 10 years. Only three years ago, the market for endoscopic surgical instruments was expected to double its size in five years. Growth beyond five years also looked promising. Largo Healthcare Company, Meditech's parent company, decided to spin Meditech off as an independent company focused solely on producing and selling endoscopic surgical instruments. Largo management hoped that the new company would prosper without the distractions of other Largo businesses and capture market share of endoscopic instruments as quickly as possible.

Since its inception just over six years ago, Meditech has produced innovative, low-cost products. New products were brought to the market quickly and pushed by an aggressive sales force. Old products were updated with innovative features and presented to the market as new products. Consequently, the competition between Meditech and National Medical centered on the continuous development and introduction of new products by both companies. A dozen or more new products would typically be introduced by Meditech in any given year.

While the development strategies were similar, the sales strategies differed dramatically. National Medical concentrated on selling to surgeons. Meditech's sales force concentrated on selling to hospitals material managers as well as to surgeons. Material managers tended to be more concerned with cost and delivery performance. The surgeons, on the other hand, focused on product features. As the pressures increased on health care costs, the importance of the material manager's purchasing position also increased. Meditech was well positioned to take advantage of this important shift.

The success of Meditech's strategy quickly became evident. Within six years, Meditech had captured the leading share in the endoscopic surgical instrument market. This was no small feat by any market's standards, but with surgical instruments this was especially impressive. Market share changes in the professional health care industry tended to take place gradually. Surgeons and doctors often held onto preferred manufacturers. Hospitals frequently used group purchasing organizations (GPOs) that took advantage of extended contracts with suppliers. The process of "converting" a hospital to a new supplier often took months of negotiation and convincing.

Most endoscopic surgical instruments are small enough to fit into the palm of a surgeon's hand. They are mechanical in nature, typically having several intricate mechanisms to provide the required functionality. Materials used to produce the instruments include plastic injection–molded parts, metal blades, springs, and so forth. In all cases of use, surgeons use the instrument for one operation and then immediately dispose of it. Instruments are never resterilized and reused for another patient. All in all, the Meditech product line consists of over 200 separate end-products.

DISTRIBUTION

Meditech distributes all its goods from a central warehouse, using two primary channels—domestic dealers and international affiliates—to distribute its products from the central warehouse to end-customers (i.e., hospitals). The first channel, for domestic sales only, uses domestic distributors, or dealers, to ship to hospitals. The dealers order and receive products from multiple manufacturers, including Meditech, typically stocking hundreds of different products. Stocked products range from commodity items, such as surgical gloves and aspirin, to endoscopic surgical instruments. By using dealers to supply products, hospitals do not need to order directly from manufacturers for their diverse needs. Additionally, since dealers maintain regional warehouses all over the United States, the distance between dealer warehouses and most hospitals tends to be quite small. The short distance permits frequent replenishments of hospital inventories; in some cases, trucks from dealers drop off supplies once or twice per day. Hospitals enjoy the frequent replenishments, which reduce hospital inventory and, consequently, reduce material costs.

The regional dealer warehouses act as independent entities, autonomously determining when to order new supplies and how much to order. Therefore, while Meditech only uses four or five major distribution companies, it still receives orders from, and ships to, hundreds of regional, individually run warehouses. Each warehouse in turn ships to about a dozen or more hospitals, resulting in thousands of hospitals that receive Meditech products.

The distribution channel for international sales uses Largo Healthcare's international affiliates. International affiliates are wholly owned subsidiaries of Largo Healthcare residing outside of the United States. As with domestic dealers, affiliates distribute to hospitals in their regional area. However, in contrast with domestic dealers, which may locate within just a few miles of customer hospitals, an affiliate ships product throughout an entire country. From Meditech's point of view, affiliates' orders essentially look no different than dealers'—international affiliates submit orders to Meditech and Meditech fills them with available product.

INTERNAL OPERATIONS

The production processes to manufacture endoscopic instruments are composed of three major steps: assembling of component parts into individual or "bulk" instruments, packaging one or more bulk instruments into a packaged good, and sterilizing the packaged goods. Each of these steps is described below.

Assembly

The assembly process is manually intensive. Component parts arrive into the assembly area from suppliers following a brief inspection by Quality

Assurance (QA). The parts are placed into inventory until ready for use by one of several assembly lines. Each assembly line is run by a team of cross-trained production workers who can produce any of several instruments within a product family. Line changeovers within a family are quick and inexpensive, merely requiring a warning from the production team leader and a supply of the appropriate component parts. The typical cycle time for assembly of a batch of instruments—the time required to schedule assembly of a batch of instruments and then actually assemble them, assuming that component parts are available in component parts inventory—is on the order of two weeks. Lead time for component parts is on the order of 2–16 weeks. Assembled instruments are moved from the assembly area into bulk instrument inventory, where they wait to be packaged.

Packaging

The packaging process makes use of several large packaging machines. The machines direct bulk instruments into plastic containers and then adhere a flexible sheet of material over the top of the container. The entire plastic container is then placed into a finished 16-cardboard container and shipped immediately to the sterilizer. Capacity at the packaging area has not restricted output.

Sterilization

The sterilization process uses a large Cobalt radiation sterilizer. After batches of packaged instruments (cardboard container, plastic container, and instruments) are placed into the sterilizer, the sterilizer is turned on for about an hour. The radiation penetrates cardboard and plastic to destroy any potentially harmful contaminants. The sterilizer can sterilize as much product as will fit inside its four walls. Capacity limitations have not been a problem thus far. Sterilized instruments are immediately moved into finished goods inventory.

The Operations Organization

The entire operations organization reports up through the vice president of Operations, Kenneth Strangler (see Figure 1-6 for an organization chart for Operations). Functions immediately reporting to Strangler include several plant managers (one for each of Meditech's four manufacturing facilities), a director of supplier management, and a director of planning, distribution, and customer service. Other vice presidents (not shown) exist for marketing and sales, product development, and finance. All vice presidents report to the highest officer in the company, the president of Meditech. The plant managers in the organization have responsibility for production personnel, engineering

Figure 1-6

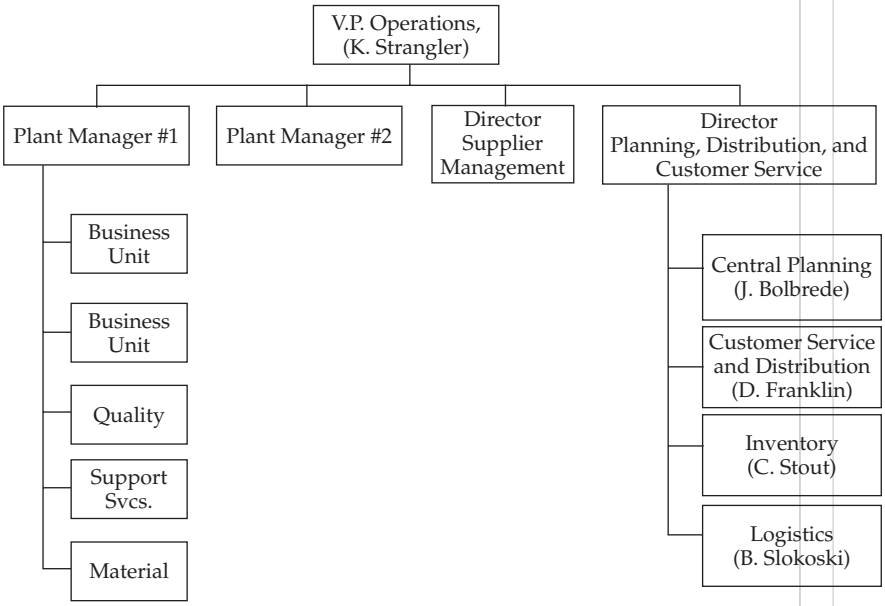

FIGURE 1-6 The Meditech Organization Chart for operations.

technicians, quality assurance, support services, and material supply for their respective facilities. Reporting directly to the plant managers are several business units. Each business unit has full responsibility either for the assembly of a particular product family or, in the case of packaging and sterilization, for an entire production process. The most important job of each assembly business unit is to meet the production schedule every week. Meeting the schedule ensures a constant supply of bulk instruments to the packaging/sterilization process. The process of determining assembly and packaging/sterilization schedules will be discussed below.

Also reporting to the vice president of Operations are Supplier Management and Planning, Distribution, and Customer Service. Supplier Management works on relationships with suppliers, including establishing purchasing contracts and finding new suppliers if necessary. The Planning, Distribution, and Customer Service department does everything it can to ensure that customers receive product when needed. The positions within the Customer Service department include the manager of Customer Service and Distribution, Dan Franklin; the manager of Central Planning; the manager of Inventory; and a manager of Logistics. Customer Service deals with everything from occasional customer complaints to establishing strategies to improve delivery service to customers. Customer Service representatives work with dealers and affiliates to keep them updated on product delivery schedules and problems. Often this responsibility places the Customer Service representative in direct contact with hospital personnel.

While Customer Service handles issues concerning the movement of product out of finished goods inventory, Central Planning ensures that adequate finished goods are available to meet incoming orders. They develop monthly production plans that are used by the business units to determine weekly and daily schedules.

Charles Stout, the Inventory manager, determines the finished goods inventory policy and establishes parts and bulk inventory guidelines for the business units. When a mandate to reduce inventory is passed down from higher levels of management, the Inventory manager must determine where inventory can be reduced and then begin enforcing those reductions. Through recent efforts, Stout had successfully eliminated several million dollars of obsolete and slow-moving inventory.

PRODUCTION PLANNING AND SCHEDULING

The production planning and scheduling process is broken down into two parts: planning, based on monthly forecasts, of assembly and component parts orders and daily scheduling of packaging and sterilization based on finished goods inventory levels. During the fourth quarter of each fiscal year, the marketing and finance organizations determine an annual forecast. The annual forecast is then broken down proportionately, based on the number of weeks in the month, into monthly forecasts. As the year progresses, the Central Planners work with the Marketing organization to make forecast adjustments according to market trends and events. At the beginning of each month, the month's forecasts are adjusted and agreed upon by the Marketing organization and the Central Planners.

The planning of assembly for a particular instrument begins with the monthly demand forecasts. Based on the month's forecast, the Central Planners determine the amount of product that needs to be transferred from bulk inventory into finished goods inventory to "meet" the expected demand. This amount, termed the finished goods "transfer requirement," is determined by subtracting the current finished goods inventory level from (1) the demand forecast for the month plus (2) the required safety stock. (The current safety stock policy is to maintain three weeks' worth of demand).

The transfer requirements, once completed for all 200-plus product codes, are passed throughout the organization for approval. This process typically takes place one to two weeks into the current month. While not actually used to schedule assembly or to alter the packaging and sterilization processes, the transfer requirements provide an estimate of the required overall production for the month. Any problems in being able to deliver to the plan can then be identified and resolved.

Assembly schedules and replenishment orders for parts are based on the monthly demand forecasts and current inventory levels. By mid-month, the completed monthly plans, which contain the monthly forecasts, are sent to the assembly business units. A planner in the business unit plugs the forecasts into a Materials Requirement Planning (MRP) system,

which determines weekly production schedules and component parts orders for each finished product. The MRP system determines assembly schedules and parts orders based on (1) the monthly forecasts; (2) the lead times for assembly, packaging, and sterilization; and (3) current parts, bulk, and finished goods inventory levels. Although the MRP calculation may be run several times each week, the planner is careful not to change weekly production schedules with less than a week's notice. (A schedule change often requires rescheduling workers and procuring more component parts. One week's notice for responding to scheduling changes, therefore, has been deemed adequate by the business unit managers.)

In contrast to the forecast-based scheduling of the assembly operation, the packaging and sterilization operations are scheduled based on as-needed replenishment of finished goods inventory. For purposes of scheduling, the packaging and sterilization operations are considered one operation because bulk instruments flow through packaging, into the sterilizer, and into finished goods without being inventoried. (See Figure 1-7 for a diagram of the entire production process.) The entire packaging/sterilization process can be completed for a batch of instruments in about one week. The scheduling of packaging/sterilization is done on an order point/order quantity (OP/OQ) basis. [I.e., when finished goods inventory drops below the predetermined order point (OP), a replenishment order for more packaged/sterilized product is initiated. The size of the order in terms of number of instruments is always equal to the predetermined order quantity (OQ).]

Figure 1-7

Another way to view the scheduling process is to think of material as being "pushed" through assembly into bulk instrument inventory and as being "pulled" through packaging/sterilization into finished goods inventory. The push through assembly is based on the monthly forecast determined before the month's demand actually arrives. The pull through packaging/sterilization simply replenishes what was sold from finished goods the day before.

NEW PRODUCT INTRODUCTIONS, HIGH LEVELS OF INVENTORY, AND POOR SERVICE LEVEL

Over the past several years, Meditech has introduced dozens of new products into the market, mostly by updating existing products. Meditech plans to continue this strategy of continuously obsoleting its own products by constantly introducing innovations. While the innovative products have been well accepted by the marketplace, each new product introduction has resulted in a nightmare of supply problems. Dan Franklin felt that customers were beginning to tire of the poor service resulting from each introduction. Through many meetings with hospital material managers, Dan began to realize the full scope of his customers' frustrations.

Franklin could not figure out why Meditech consistently had shortages with each introduction. Forecasting had definitely been a problem, but determining its extent was difficult. Data to measure forecast accuracy had not previously been tracked, nor had forecasts and demand information been kept. Data gathering requires a lengthy process of going back through hard copies of prior monthly plans and entering the information by hand into a computer. Even if a better methodology could be determined, forecasts can only be improved by so much.

In addition to new product introduction problems, finished goods inventory levels appeared to be remarkably high. A consultant had recently been hired to study Meditech's inventory. Her findings indicated that overall inventory could be reduced by at least 40 percent without an impact on the delivery

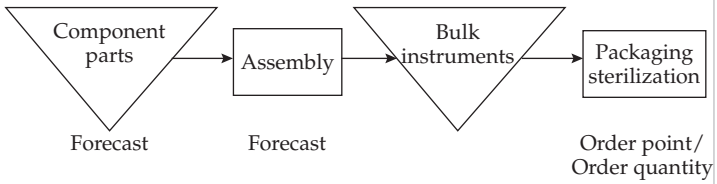

FIGURE 1-7 The Meditech production process.

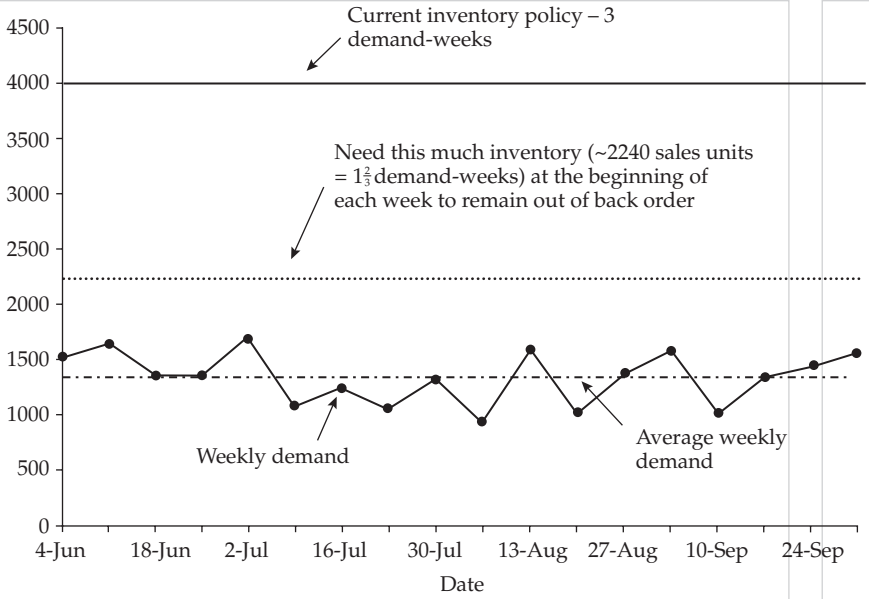

FIGURE 1-8 Weekly demand pattern for a representative stable product demonstrating current levels of inventory versus consultant's recommended inventory policy.

Figure 1-8 Footnote 1

service level (see Figure 1-8).[1] Despite the high levels of inventory, the actual service level over the past year was disappointing and below corporate objectives. Management feared that reducing inventory would further damage the already subpar level performance.

Another possible cause of the problem is "panic ordering" from dealers and affiliates. Panic ordering occurs when a dealer or affiliate is unsure of whether or not product will be received in time and therefore increases the size of its orders hoping that Meditech will deliver at least part of the order. The increased orders would cause demand to temporarily rise, helping to explain Meditech's problems with demand consistently exceeding supply. Familiar with past delivery problems, dealers and affiliates had every reason to want to panic order. In one conversation with a representative from Meditech's largest dealer, the representative had indicated that panic ordering was a possibility. Given the decentralized nature of the regional warehouses, the dealer has little control over what an individual warehouse actually orders. Warehouses could therefore panic order without the knowledge of the central dealer. On the other hand, the possibility of panic ordering does not mean that it actually occurs. To make matters worse, data proving or disproving its existence had been hard to find.

Dan asked one of his staff members to investigate the new product introduction problem and inventory/service level paradox. The staff member spent several months compiling information on demand patterns, production rates, and forecasts. Consistent with Meditech's decentralized nature, the information existed on many different systems in several different areas of the organization. There was no routine way to see incoming demand, inventory, or production rates for a particular instrument. Developing a common format for the data had also been difficult. Some data were expressed in terms of calendar months, other data in terms of weeks, and still other data in terms of the corporate financial calendar (alternating 4-week, 4-week, and 5-week months). Once put together, the information conveyed the following:

[1]Note on replenishment assumption: For simplicity, this chart assumes that finished goods (FG) inventory is replenished once per week with a lead time of one week. At the beginning of each week, enough product is "ordered" so that the "pipeline" plus FG inventory equals $^2/_3$ demand-weeks of product. The pipeline in this case refers to in-process product that has not yet reached FG inventory. On average, one week's worth of demand will reside in the pipeline. This leaves, again on average, $2^2/_3 - 1 = 1^2/_3$ demand-weeks in FG inventory at the beginning of each week.

FIGURE 1-9 Typical demand pattern for a new product introduction. The product was officially introduced near the end of week #4.

- New product demand after an introduction followed a consistent pattern of reaching a high peak during the first few weeks, but becoming relatively stable immediately afterward (see Figure 1-9).
- Variation in production schedules often exceeded variation in demand (see Figures 1-10 and 1-11).
- Monthly forecasting could be improved substantially using a simple statistical method: generating a linear regression through past data. With

Figure 1-9

Figure 1-10
Figure 1-11

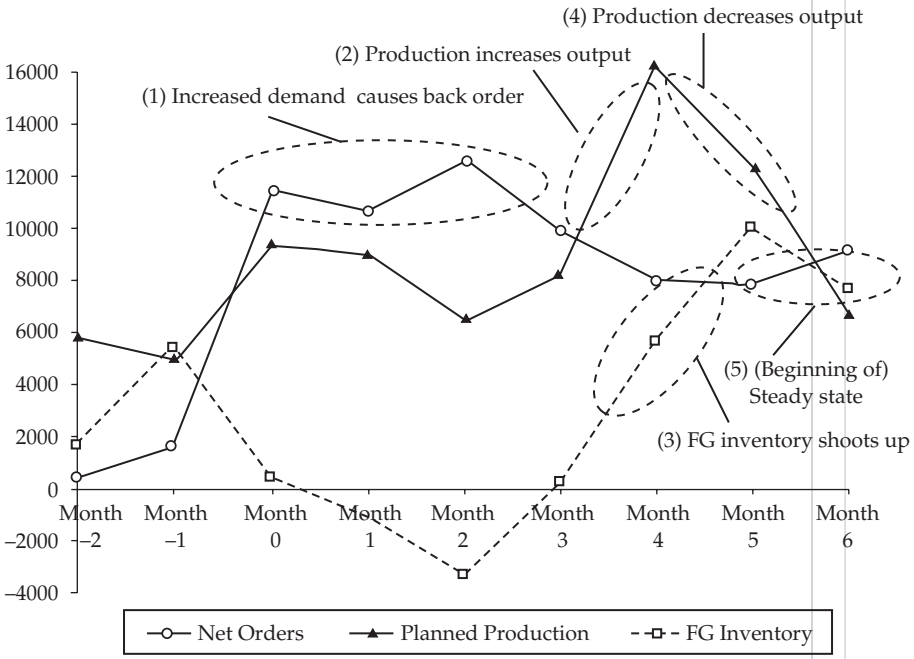

FIGURE 1-10 Production reaction to a new product introduction. The product was introduced in the last 2 weeks of Month 0.

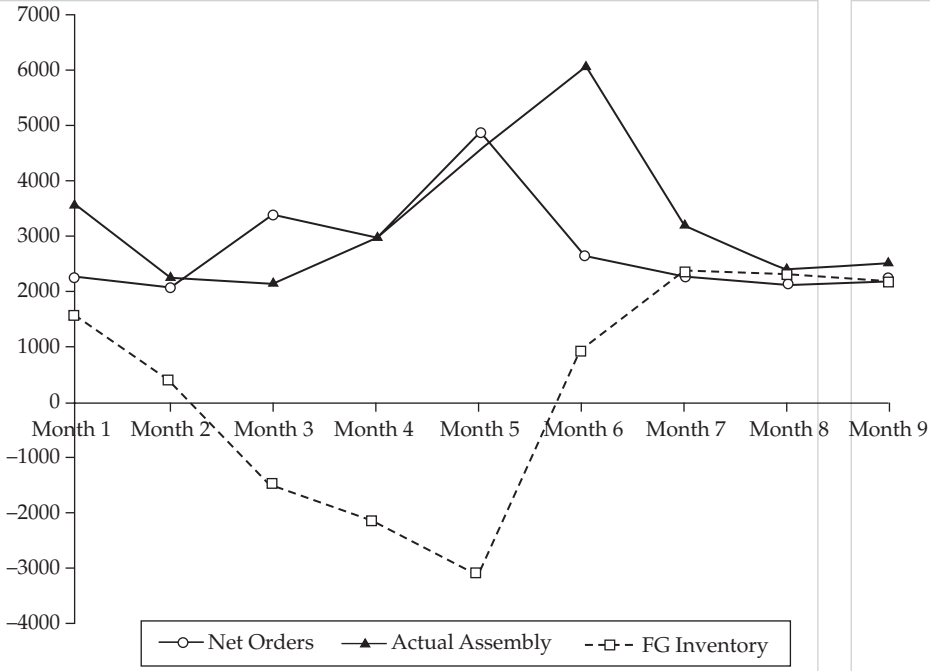

FIGURE 1-11 Production reaction to unexpectedly high demand (not a new product introduction). The unexpected demand occurred during Month 3, Month 4, and Month 5. Note that only monthly assembly output is shown; packaging/sterilization output was not obtained.

this information in mind, Dan Franklin began thinking about how to fix Meditech's delivery problems.

CASE DISCUSSION QUESTIONS

1. What are Meditech's problems in introducing new products? In manufacturing ALL products?
2. What is driving these problems, both systemically and organizationally?
3. Why is the customer service manager the first person to recognize the major issues?
4. How would you fix these problems?