CHAPTER

2

Supply Chain Management

Learning Objectives

After reading this chapter, you will be able to:

- **LO1** define the nature and strategic importance of supply chains, and their linkage to core processes, namely supplier relationship, order fulfillment, and customer relationship processes.
- **LO2** define the key design issues.
- **LO3** distinguish between efficient and responsive supply chains and understand how each offers particular competitive benefits in different business settings.
- **LO4** explain why managers might choose a supply chain strategy that includes outsourcing, offshoring, or vertical integration.
- **LO5** measure performance of supply chains.
- **LO6** describe the major causes of supply chain dynamics, their effects, and options to improve performance.

Across the Organization

Supply chain management is important to:

- **distribution,** which determines the best placement of finished goods inventories and selects the appropriate modes of transportation for serving the external supply chain.
- **marketing,** which involves contact with the firm's customers and needs a supply chain that ensures responsive customer service.
- **operations,** which is responsible for managing effective supply chains.
- **purchasing,** which selects the suppliers for the supply chain.
- **finance and accounting,** which must understand how the performance of the supply chain affects key financial measures and how information flows into the billing process.

With revenues of over $10 billion in 2013, Nikon produces precision optical instruments in four major divisions. Each has its own supply chain because both the suppliers and operational requirements differ. Let's look more closely at just a few recent improvements in one division, Imaging Products, which includes a host of digital SLR cameras, interchangeable lenses, and Coolpix compact cameras.

Imaging Products has a great deal of volatility caused by technological innovation, aggressive competition, and changing customer definitions of value. To respond to this volatility, the existing supply chain had to be redesigned to be more flexible and faster. Looking downstream, Nikon wanted to have the capability to deliver those products to retailers quickly so that they could keep up with demand from tech-savvy consumers and professional photographers. Upstream, the company wanted to develop a supply chain network that could be both innovative and responsive, improve customer value, and minimize supply chain-related risks.

Caption FPO

Downstream, Nikon took the rare step of outsourcing the distribution of an entire consumer electronics product line to a third-party logistics provider (3PL). While Nikon had previously handled new-product distribution in-house, United Parcel Service (UPS) now handles the logistics of shipping this product line via air or ocean freight from manufacturing sites in Asia, through U.S. customs, to Kentucky, which serves as the all-points connection for UPS's global operations. Here, some of the final assembly operations also are performed. For example, accessories such as batteries and chargers can be added, or products can be repackaged to meet the requirements for retail displays. Finally, the products are shipped to thousands of retail outlets throughout countries across North American and the Caribbean.

Upstream, until recently, Nikon's manufacturing facility in Thailand produced virtually all its digital SLR cameras. Unfortunately, the disastrous flooding in October 2011 halted production and forced three months of rebuilding. Sales suffered significantly, despite help from local supply chain partners to maintain limited production. To mitigate such risks in the future, Nikon constructed a new assembly plant in Laos in 2013 to take over some stages of the manufacturing process for the bodies of digital SLR cameras. Half-finished assemblies from the Laotian factory are then shipped to Thailand to be made into final products.

Combined with other changes, Nikon's redesigned supply chain has improved the flow of products from origin to destination, reduced risk, lowered costs, and offered more precise information about inventories in the supply chain. Armed with this information, managers can adjust delivery times to accommodate sales opportunities that otherwise would be missed. Despite the growing complexity of the supply chain—with more plants, suppliers and distribution partners—products leaving Nikon manufacturing facilities can now be on a retailer's shelves in as few as two days.[1]

supply chain management
The synchronization of a firm's processes with those of its suppliers and customers to match the flow of materials, services, and information with customer demand.

Supply chain management seeks to synchronize a firm's processes and those of its suppliers and customers to match the flow of materials, services, and information with customer demand. Supply chain management has strategic implications, because the supply system can be used to achieve important competitive priorities, as with Nikon. Key processes must be tightly coordinated, including customer relationships, order fulfillment, and supplier relationship processes. It is important to note, however, that a firm such as Nikon might have multiple supply chains, depending on the specific mix of services and

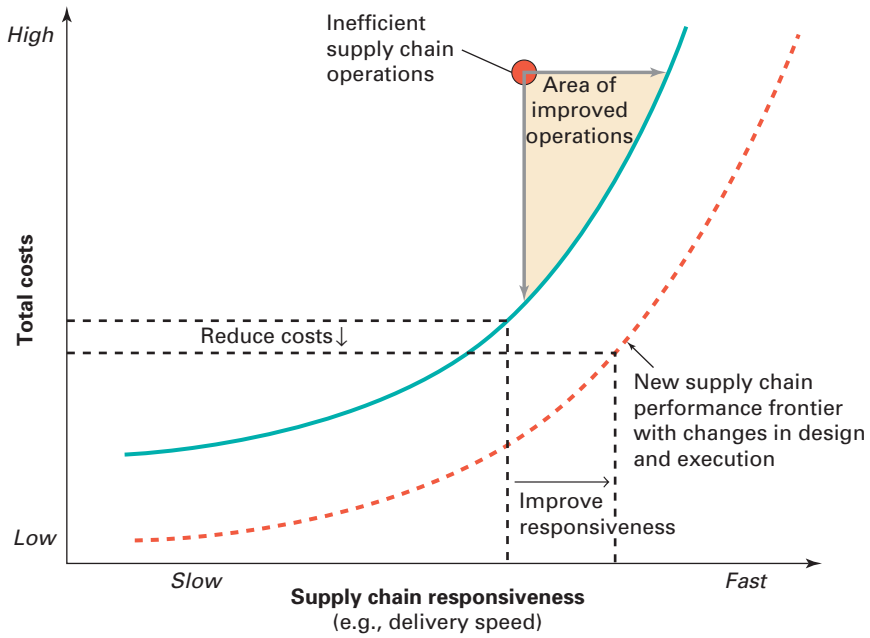
products being offered to customers. As a result, a supplier might be involved in only a small number of supply chains, along with other suppliers that serve many different supply chains, including those of competitors. The firm's operations strategy and competitive priorities must guide its supply chain decisions.

To get a better understanding of the importance of supply chain management, consider Figure 2.1, which conceptually shows the challenges facing operations managers. The blue line is the performance curve (sometimes called the efficiency frontier) that shows the trade-off between costs and supply chain responsiveness, such as delivery speed, for the current supply chain design if the supply chain is operated as efficiently as possible. This curve illustrates the best possible performance when we consider all of the leading firms in the same industry. (Of course, other competitive priorities, such as quality or flexibility, could be substituted for the horizontal axis.)

Now, suppose that your firm plots its actual costs and responsiveness, as indicated by the red dot. It is far off of the performance frontier, which is not an uncommon occurrence. The challenge is to move operations into the tinted area, as close to the frontier as possible. This change in position can be accomplished using a better supply chain design, superior quality processes, more accurate planning, and leaner operations systems. We discuss these topics in the chapters that follow. In addition, if new competitive innovations are developed, the firm might be able to push the entire performance frontier outward, as shown by the dashed red line. Amazon is such an example: using innovative supply chain processes, it created an extremely responsive supply chain, which in turn pushed the rest of the retail industry to perform better. In essence, the goal is to reduce costs as well as increase other dimensions of customer value.

We begin by taking a bird's-eye view of supply chain management, focusing on its implications for service providers and manufacturers. We then describe how companies manage their customer and supplier interfaces. Next, we discuss the important operating and financial measures of supply chain performance, followed by a discussion of the dynamics of supply chains. We conclude with a comparison of basic supply chain designs, their competitive implications, and options for structuring supply chains.

FIGURE 2.1 *Supply Chain Efficiency Curve*



LO1 Define the nature and strategic importance of supply chains, and their linkage to core processes, namely supplier relationship, order fulfillment, and customer relationship processes.

SUPPLY CHAIN STRATEGIES

As we saw with Nikon at the beginning of this chapter, firms rarely operate in isolation to produce services or goods. Working with suppliers, distributors, and other supply chain partners, a firm must design and implement a strategy for its supply chain.

LINKING FIRMS TO DELIVER VALUE

Supply chain design is driven by the need to provide support for the essential elements of the customer benefit bundle offered by a firm. Recall that a customer benefit bundle consists of a core service or product along with a set of peripheral products and services. Management must design and leverage the firm's supply chain both to acquire supporting goods and services and to reach the customer.

To see the connection between supply chains and customer benefit bundle, consider the example of atWork Office Furniture (www.atwork.ca), a service provider that offers customized office design and a wide variety of business furnishings, from a single workstation to an entire office. Customers can view new and used furniture online, consult with staff using a 1-800 number, or visit one of five retail locations across Ontario. The new furnishings are sourced globally, and used products are acquired from many local businesses (essentially suppliers, who, in turn, are likely to be customers).

A simplified supply chain for this firm is illustrated in Figure 2.2, which shows how the suppliers support various elements of the service. Each of the suppliers, of course, has its own supply chain. For example, a supplier of chairs might get composite tubing from one supplier and leather from another. All of the suppliers in this firm's supply chain play

FIGURE 2.2 *Supply Chain for an Office Furniture Retailer*

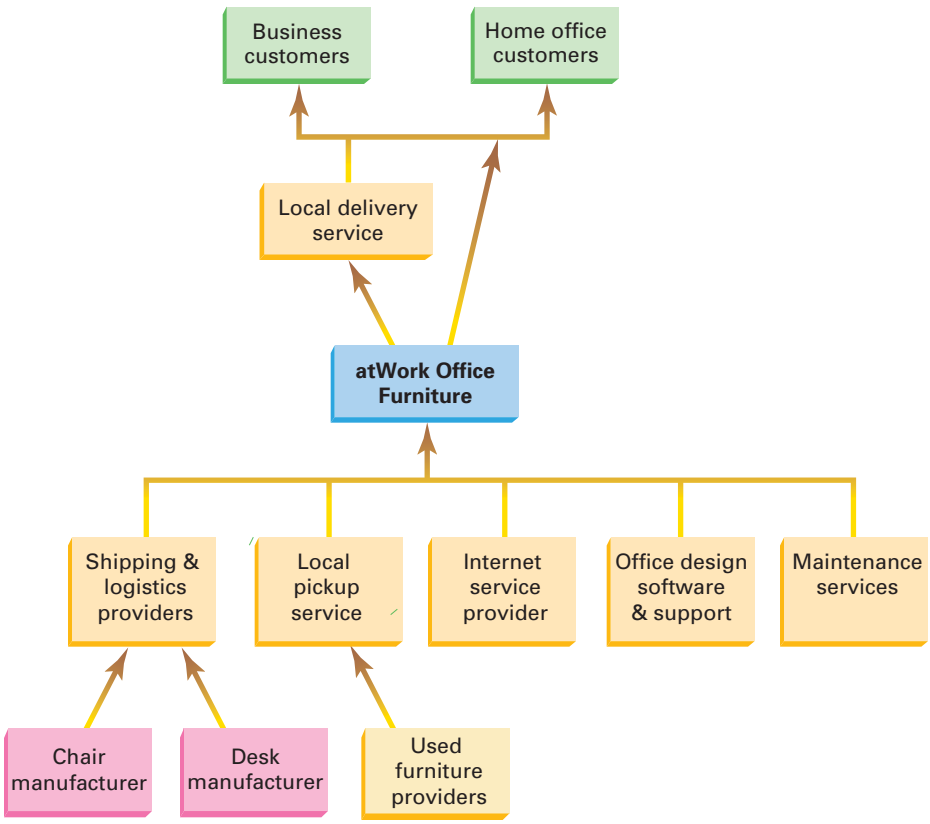
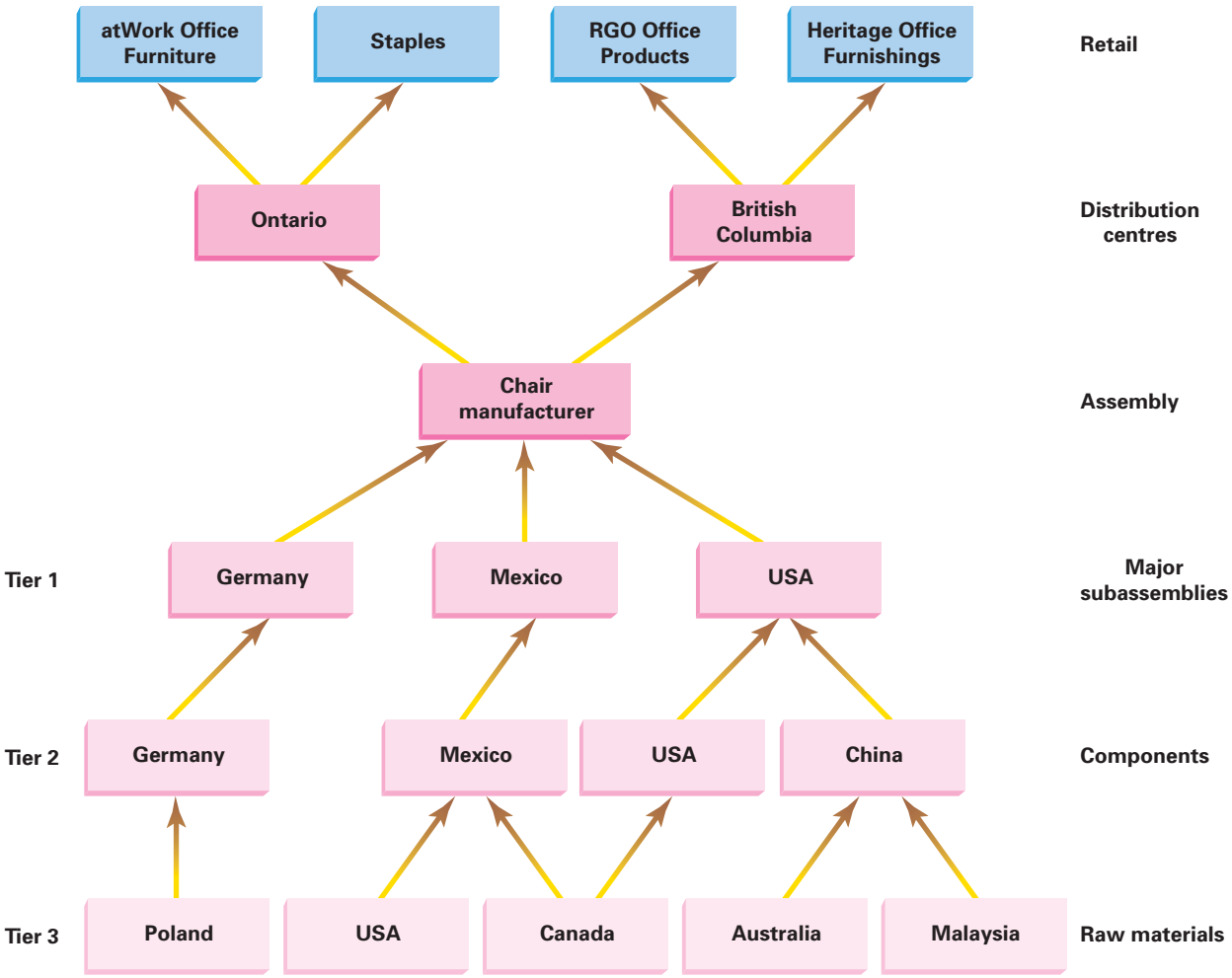


FIGURE 2.3 *Supply Chain for a Manufacturing Firm*



an integral role in its ability to meet its competitive priorities for the customer benefit bundle, such as high-performance design, delivery speed, and customization.

As the degree of customer interaction increases in the service process, the complexity and challenges also tend to increase. For example, an airline's supply chain provides soft drinks, peanuts, in-flight meals, and airsickness bags, as well as maintenance and repair items such as engine parts and motor lubricants. Timing and coordination in this supply chain are often very visible to customers, and any miscues are immediately evident and often interpreted as poor service.

The supply chain for manufacturing firms, such as the chair manufacturer shown at the bottom of Figure 2.2, can also be very complicated because many companies have hundreds, if not thousands, of suppliers. (Figure 2.3 is a generalization.) Suppliers are often identified by their position in the supply chain relative to the primary firm of interest. In Figure 2.3, the primary firm is the chair manufacturer, and tier 1 suppliers provide materials or services that are used directly by the firm; tier 2 suppliers supply tier 1 suppliers, and so on. In this diagram, the firm owns its own distribution and transportation services. However, companies that engineer products to customer

TABLE 2.1 *Business Settings Best Suited for Efficient and Responsive Supply Chains*

FACTOR	EFFICIENT SUPPLY CHAINS	RESPONSIVE SUPPLY CHAINS
Demand	Predictable; low forecast errors	Unpredictable; high forecast errors
Competitive priorities	Low cost; consistent quality; on-time delivery	High innovation; fast delivery times; customization; volume flexibility; high-performance design quality
New-product introduction	Infrequent	Frequent
Contribution margins	Low	High
Product variety	Low	High

specifications normally do not have distribution centres as part of their supply chains. Such companies often ship products directly to their customers.

The value of careful design and consistent execution for supply chain management becomes apparent when the complexity of the supply chain is recognized. However, the challenges don't stop here. As is evident from Figures 2.2 and 2.3, *each* firm in the chain must build its own supply chain with a consistent understanding and support for the competitive priorities of the overall supply chain. This challenge helps to explain why the performance of many supply chains has been dismal, with high costs and slow response times, despite great investment in advanced technologies such as the Internet, flexible manufacturing, and automated warehousing. For example, the design of supply chain for a firm with innovative, customized high-margin products, like the Boeing 787 described later, should be quite different from that of another firm providing basic, functional, low-margin products, like a Toyota Yaris. Overall, the design of the supply chain must be aligned with a firm's strategy and the characteristics of specific products or services.

EFFICIENT VERSUS RESPONSIVE SUPPLY CHAINS

Depending on the characteristics of the product or service, two distinct supply chain designs can be used for competitive advantage: *efficient* or *responsive* supply chains. The pattern of demand for the firm's product or service is a key factor in the best choice of supply chain design. The purpose of efficient supply chains is to coordinate the flow of materials and services so as to minimize inventories and maximize the efficiency of the chain. Responsive supply chains are designed to react quickly to market demands by positioning inventories and investing in flexible capacity to hedge against variation and uncertainties in demand. Table 2.1 summarizes several key factors that influence each design.

EFFICIENT SUPPLY CHAINS. Efficient supply chains work best in settings where demand is highly predictable, such as demand for staple items purchased at grocery stores or demand for a package delivery service. The focus of the supply chain is on the efficient flows of materials and services, that is, keeping inventories to a minimum. Product or service designs last a long time, new introductions are infrequent, and variety is small. Such firms typically produce for markets in which price is crucial to winning an order; therefore, contribution margins are low and efficiency is important. As a result, manufacturing firms serve customers from a finished goods inventory. Consequently, the firm's competitive priorities are low-cost operations, consistent quality, and on-time delivery.

TABLE 2.2 *Design Features for Efficient and Responsive Supply Chains*

FACTOR	EFFICIENT SUPPLY CHAINS	RESPONSIVE SUPPLY CHAINS
Operations strategy	Emphasize high-volume, standardized products or services, such as make-to-stock	Emphasize product or service variety, including assemble-to-order, make-to-order, or customization
Inventory investment	Low; focus on high inventory turnover	Higher at critical points in supply chain to enable fast delivery time; use modular components
Lead time	Shorten, if possible without driving up cost	Shorten aggressively
Supplier selection	Emphasize low prices, consistent quality, on-time delivery	Emphasize fast delivery time, customization, volume flexibility, high-performance design quality

RESPONSIVE SUPPLY CHAINS. Responsive supply chains work best when firms offer a great variety of products or services and demand predictability is low. Demand may also be short-lived, as in the case of fashion goods. The focus of responsive supply chains is reaction time to meet rapidly changing demand, with judiciously placed inventories along the supply chain to meet peak demand. In other markets, firms may not know what products or services they need to provide until customers place orders. Firms can respond by assembling service packages or making products to fill specific orders. To be competitive, such firms must frequently develop new products or services to generate high contribution margins. Typical competitive priorities are development speed, fast delivery times, customization, volume flexibility, and high-performance design quality.

IMPLEMENTING THE RIGHT DESIGN

The alignment with operations strategy and implementation for efficient and responsive supply chains are summarized in Table 2.2. The further upstream in an efficient supply chain that a firm is positioned, the more likely it is to have a process that supports high volumes of standardized products or services. Consequently, suppliers in efficient supply chains tend to have little excess capacity because high utilization helps to keep the cost per unit low. Higher inventory turnover is desired to keep inventory investment low, and thus reduce costs. Firms should work with their suppliers to shorten lead times, but care must be taken to use tactics that do not appreciably increase costs. For example, lead times for a supplier could be shortened by switching from rail to air transportation; however, the added cost may offset the savings obtained from the shorter lead times. Suppliers should be selected with emphasis on low prices, consistent quality, and on-time delivery. Because of low capacity cushions, disruptions in an efficient supply chain can be costly and must be avoided.

Because of the need for quick reactions and the high levels of product or service variety, firms in a responsive supply chain must have a more flexible process. Consequently, suppliers also tend to have very flexible operations. Inventories should be positioned in the chain to support delivery speed, but inventories of expensive finished goods should be avoided. Firms should aggressively work with their suppliers to shorten lead times because that allows managers to wait longer before committing to a customer order—in other words, it gives them flexibility. Firms should select suppliers to support the competitive priorities of the products or services provided, which in this

case would include the ability to provide quick deliveries, customize parts or components, adjust volumes quickly to match demand cycles in the market, and provide high performance quality.

Poor supply chain performance is often the result of using the wrong supply chain design for the products or services provided. A common mistake is to use an efficient supply chain in a business setting that calls for a responsive supply chain or, alternatively, a single design across all market segments. Instead, a firm may need to utilize more than one supply chain design when its operations compete in multiple market segments. For example, the supply chain for a standard product such as an oil tanker has different requirements than that for a customized product such as a luxury liner, even though both are ocean vessels and both may be manufactured by the same company.

Finally, the design of supply chains becomes more complex as markets evolve and firms move to reposition products over time. Over time, a firm may add options to its basic product, or introduce variations of that product, so that the variety of products and options increases dramatically. Yet, all too often, the design of the supply chain changes little, and the firm continues to measure the supply chain's performance as it always has, emphasizing efficiency, even when characteristics of the product and market require a more responsive supply chain design.

For some firms, an intermediate design step is to identify modular subassemblies or service elements that can be combined using postponement. For example, Gillette uses an efficient supply chain to manufacture some products so that it can more fully utilize a capital-intensive manufacturing process. However, in response to increasingly uncertain and fragmented retail markets, managers have developed a supply chain that postpones the packaging of the products until the very last moment. The packaging operation involves customization in the form of printing different graphics and languages. Just as a process can be broken into parts, a supply chain can be segmented to achieve better performance.

OUTSOURCING PROCESSES

outsourcing Using payment to suppliers and distributors to provide needed services and material.

make-or-buy decisions Decisions that involve either more integration (a *make* decision) or more outsourcing (a *buy* decision).

All businesses buy at least some inputs, such as professional services, raw materials, or manufactured parts, from other producers. Termed **outsourcing**, this means that the firm must pay suppliers and distributors to perform these processes and provide needed services and materials. Conversely, vertical integration is the degree to which a firm's own production system or service facility handles the entire supply chain. The more processes in a supply chain that a firm performs for itself, the greater the degree of vertical integration. Thus, as managers opt for more vertical integration, there is by definition less outsourcing. These decisions are sometimes called **make-or-buy decisions**, with a *make* decision meaning more integration and a *buy* decision meaning more outsourcing. After deciding what to outsource and what to do in-house, management must find ways to coordinate and integrate the various processes and suppliers involved.

BREAK-EVEN ANALYSIS FOR MAKE-OR-BUY DECISIONS. Often, choices must be made between two processes or between an internal process and buying services or materials from a supply chain partner. To begin, we assume that the decision does not affect revenue, and we focus on all relevant costs. To do so, the analyst finds the quantity for which the total cost of "buy" equals the total cost of "make."

Let F_b equal the fixed cost (per year) of the buy option, F_m equal the fixed cost of the make option, c_b equal the variable cost (per unit) of the buy option, and c_m equal the variable cost of the make option. Finally, Q is the quantity needed annually. Thus,

the total cost to buy is $F_b + c_bQ$, and the total cost to make is $F_m + c_mQ$. To find the break-even quantity, we set the two total costs equal, and solve for Q:

$$F_b + c_bQ = F_m + c_mQ$$

$$Q = \frac{F_m - F_b}{c_b - c_m}$$

EXAMPLE 2.1 *Using Break-Even Analysis for the Outsourcing Decision*

Thompson manufacturing produces industrial scales for the electronics industry. Management is considering outsourcing the shipping operation to a logistics provider experienced in the electronics industry. Thompson's annual fixed costs of the shipping operation are $1 500 000, which includes costs of the equipment and infrastructure for the operation. The estimated variable cost of shipping the scales with the in-house operation is $4.50 per tonne-kilometre. If Thompson outsourced the operation to Carter Trucking, the annual fixed costs of the infrastructure and management time needed to manage the contract would be $250 000. Carter would charge $8.50 per tonne-kilometre. What is the break-even quantity?

SOLUTION

The formula for break-even quantity yields

$$Q = \frac{F_m - F_b}{c_b - c_m}$$

$$= \frac{1\,500\,000 - 250\,000}{8.50 - 4.50} = 312\,500 \text{ ton-miles.}$$

Decision Point Thompson management must now assess how many tonne-kilometres of product will likely be shipped now and in the future. If that estimate is less than 312 500 tonne-kilometres, the best option is to outsource the operation to Carter Trucking.

The make option should be considered, ignoring qualitative factors, only if its variable costs are lower than those of the buy option. The reason is that the fixed costs for making the service or product are typically higher than the fixed costs for buying. Under these circumstances, the buy option is better if production volumes are less than the break-even quantity. Beyond that quantity, the make option becomes better.

OUTSOURCING. Firms are doing more outsourcing than ever before, and three general factors have contributed to this trend: intensifying global competition, widely available information technology, and increasingly specialized operational capabilities. Outsourcing can offer several advantages to firms, such as better quality and cost savings. For example, foreign locations managed by a supplier can offer lower wages and yield higher productivity. This approach can also be attractive to firms with low volumes of specific products or if specialized expertise is needed. Globalization creates more supplier options, and advances in information technology make coordination with suppliers easier.

IKEA, the largest retailer of home furnishings, has 30 buying offices around the world to seek out suppliers. Its Vienna-based business service department runs a

computer database that helps suppliers locate raw materials and new business partners. Cash registers at its stores around the world relay sales data to the nearest warehouse and to its operational headquarters in Älmhult, Sweden, where its information systems provide the data needed to control its shipping patterns worldwide.

offshoring A supply chain strategy that involves moving internal processes to another country, often involving an joint venture partner.

OFFSHORING. Alternatively, a firm might relocate its own processes to another country, termed **offshoring**. Firms are motivated to initiate operations offshore by the market potential and the cost advantages this move can provide. The firm may be able to create new markets because of its presence in other countries and its ability to offer competitive prices due to its cost efficiencies. The firm can offshore by investing in a wholly owned subsidiary, or as is common, by developing a joint venture with a local firm in a foreign country. In a joint venture, the two firms agree to cooperatively produce a service or product together.

Even though outsourcing and offshoring can offer some big advantages, they also have some pitfalls that firms should carefully explore before using these strategic options. First, short-term cost savings might overlook major opportunities to fix existing processes. As we will discuss in the next few chapters, there are many ways to improve processes in the areas of quality, efficiency, and customer responsiveness. (See Chapter 4, "Process Configuration," and Chapter 7, "Quality and Process Improvement.") It is not always the case that offshoring or outsourcing is the answer, even if local labour wages far exceed those of other countries.

Second, outsourcing often requires the parent firm to transfer some proprietary technology to the local partner. Unfortunately, this transfer can nurture a future competitor. For example, Chinese rail companies that were once junior partners with Japanese, European, and Canadian companies, such as Bombardier Inc., have recently been competing against them in the growing global market for super-fast train systems. According to a senior executive at Kawasaki, "How are you supposed to fight rivals when they have your technology, and their cost base is so much lower?"[2] In contrast, Nikon continues to keep much of its high-precision manufacturing in Japan rather than shift these operations to lower-cost countries elsewhere. The strategy is to compete primarily on technological innovation.

Finally, despite the power of the Internet, it is difficult to fully integrate outsourced or offshore processes with the firm's other core processes. Time, distance, and communication can be formidable hurdles that slow a firm's responsiveness to changing customer needs. For example, managing offshore processes can be much more complex than managing internal processes located close to engineering support at corporate offices. Also, local competitors might hire key people away from the offshore plant to upgrade their operations. Often considerable managerial time must be expended to coordinate offshore processes, for example, to transfer new product designs and to incorporate customer feedback into redesigning operations.

backward integration A firm's movement upstream toward the sources of raw materials and parts.

forward integration A firm's movement downstream by acquiring channels of distribution, finished goods manufacturing, or supplemental service.

VERTICAL INTEGRATION. Vertical integration can be in two directions. **Backward integration** represents movement upstream toward the sources of raw materials and parts, such as a major grocery chain having its own plants to produce house brands of ice cream, frozen pizza dough, and peanut butter. Alternatively, **forward integration** represents movement downstream, such as acquiring new channels of distribution, warehouses, and retail stores. It can also mean that a firm begins to acquire or compete against its customers. Vincor Canada, this country's largest producer of wine, is a model of vertical integration. The firm's dozens of brands run the gamut from basic to premium wines. Upstream, it owns or leases thousands of hectares of vineyards in Ontario, British Columbia, and California. Downstream, it sells its

products through its own chain of Wine Rack stores. Finally, winery tours through new state-of-the-art operations and a 500-seat amphitheatre have been developed and built to lure wine lovers and concert-goers to increase cellar-door sales in the Niagara region of Ontario.

A firm tends to choose vertical integration when it has the skills, volume, and resources to perform processes at lower cost and produce higher-quality goods and services than outsiders can. Doing the work in-house may mean better quality and more timely delivery—and taking better advantage of the firm's human resources, equipment, and space. Extensive vertical integration is generally attractive when input volumes are high, because high volumes allow for task specialization and greater efficiency. It is also attractive if the firm has the relevant skills and if it views the processes that it is integrating as particularly important to its future success. Thus, managers must look upstream toward its suppliers and downstream toward its customers, and bring in-house those processes that give it the right skills and capabilities—those that allow the firm to organize work and deliver value better than its competitors. However, management should also realize that if the firm outsources a critical process, it might lose control over that area of its business—and perhaps foster future competition.

Thus, these strategic options carry opportunities, challenges, and threats. As with any critical decision affecting operations strategy, trade-offs must be carefully assessed and risks actively managed.

LO2 Define the key design issues.

MEASURES OF SUPPLY CHAIN PERFORMANCE

Managers need performance measures to assess the implications of changes to a supply chain. Before discussing the major supply chain decisions, we define the typical inventory measures and financial measures used to monitor supply chain performance and evaluate alternative supply chain designs.

FORMS OF INVENTORY

inventory A stock of items, including materials, orders, information, and people, that flow through or are used in a process to satisfy customer demand.

raw materials Materials and items used as inputs for the production of goods and services.

work-in-process (WIP) Items partway through a process that are needed for a final product or service.

finished goods Items that have completed the manufacturing or service process.

The importance of supply chain management becomes apparent when the complexity of the supply chain is recognized. The performance of numerous suppliers determines the inward flow of materials and services to a firm. Moreover, the performance of the firm determines the outward flow of services or products to the next stage of the supply chain. Collectively, the flow of materials determines inventory levels at each firm in a supply chain. **Inventory** is a stock of items used to satisfy customer demand or support the production and delivery of goods and services. Given the wide variety of processes used by organizations, items include materials, orders, information, and people that flow through or are used in a process.

Inventory exists in three general forms: raw materials, work-in-process, or finished goods. Identifying each form is based partly on the process (Where does it start and stop?) and partly on the organization (Where do hand-offs occur and what is the degree of vertical integration?). These forms are also useful for accounting purposes. **Raw materials** are inventories needed for the production of goods or services. They are considered to be inputs to the transformation processes of the firm, whether they produce a product or a service. **Work-in-process (WIP)** consists of items such as components or assemblies needed for a final product in manufacturing. WIP is also present in service operations, such as repair shops, restaurants, cheque-processing centres, and package delivery services. **Finished goods** in manufacturing plants, warehouses, and retail outlets are the items sold to the firm's customers. The finished goods of one firm may actually be the raw materials for another.

FIGURE 2.4 *Inventory at Successive Stocking Points*

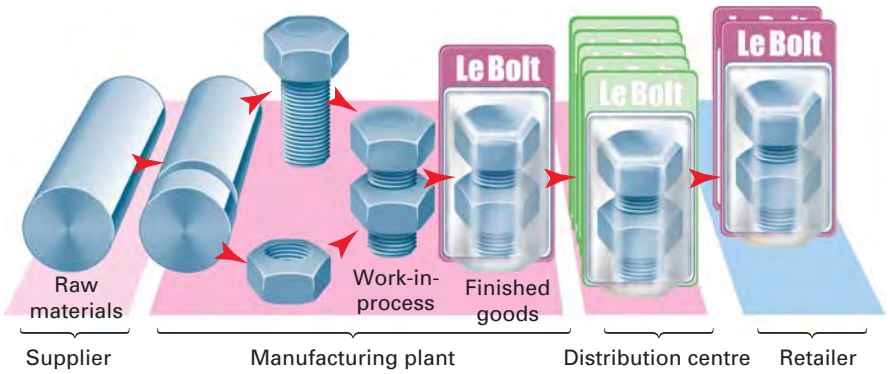


Figure 2.4 shows how inventory can be held in different forms and at various stocking points for a typical manufacturing firm. In this example, raw materials—the finished goods of the supplier—are held by both the supplier and the manufacturer. Raw materials at the plant pass through one or more processes, which transform them into various levels of WIP inventory. Final processing of this inventory yields finished goods inventory. Finished goods inventory can be held at the plant, the distribution centre (which may be a warehouse owned by the manufacturer or the retailer), and retail locations.

Imagine the chaos if a firm's suppliers and customers all acted independently and never communicated changes in demand or adjusted to changes in others' schedules. Reducing inventory and speeding the flow of goods and services in the supply chain is covered in greater detail in Chapter 8, "Lean Systems."

INVENTORY PLACEMENT

A fundamental supply chain decision is where to locate inventories of raw materials, work-in-process, or finished goods. At one extreme, the firm could keep the entire finished goods inventory at the manufacturing plant and ship directly to each of its customers. The advantage would come from what is referred to as **inventory pooling**, which is a reduction in inventory and safety stock because of the merging of variable demands from many customers. A higher-than-expected demand from one customer can be offset by a lower-than-expected demand from another. However, a disadvantage of placing the entire inventory in one location is the added cost of shipping smaller, uneconomical quantities directly to the customers, typically over long distances.

inventory pooling A reduction in inventory and safety stock because of the merging of variable demands from customers.

Another approach is to use **forward placement**, which means locating stock closer to customers at a warehouse, distribution centre (DC), wholesaler, or retailer. Forward placement can have two advantages for the order-fulfillment process—faster delivery times and reduced transportation costs—that can stimulate sales. As inventory is placed closer to the customer, such as at a DC, the pooling effect of the inventories is reduced because safety stocks for the item must increase to take care of uncertain demands at each DC, rather than just a single location. However, the time to get the product to the customer is reduced. Consequently, service to the customer is quicker, and the firm can take advantage of larger, less costly shipments to the DCs from the manufacturing plant, at the expense of larger overall inventories.

forward placement Locating stock closer to customers at a warehouse, distribution centre (DC), wholesaler, or retailer.

INVENTORY MEASURES

All methods of measuring inventory begin with a physical count of units, volume, or weight. However, measures of inventories are reported in three basic ways: average aggregate inventory value, weeks of supply, and inventory turnover.

average aggregate inventory value The total value of all items held in inventory by a firm.

First, the **average aggregate inventory value** is the total value of all items held in inventory for a firm. Consistent with accounting conventions, valuation is at cost, summing the value of individual items in raw materials, work-in-process, and finished goods. Because this measure is taken at a particular point in time, it is usually more meaningful to estimate the average inventory investment over some period of time.

The raw materials typically cost much less than a finished product, which includes the costs of labour, technology, and other value-added operations performed in manufacturing the product. For example, the value of raw materials, such as iron ore, must be added to that of finished products, such as steel coils, for a steel manufacturer. To estimate the approximate average aggregate inventory value, sum the values of individual inventory items:

$$\text{Average aggregate inventory value} = (N_a c_a) + (N_b c_b) + \ \ldots \ + (N_n c_n)$$

where

N_a = Average quantity of materials, part, component, or product a
c_a = Average cost per unit of materials, part, component, or product a
n = Total number of materials, parts, components, and products

Summed over all items in an inventory, this total value tells managers how much of a firm's assets are tied up in inventory. Manufacturing firms typically have about 25 percent of their total assets in inventory, whereas wholesalers and retailers average about 75 percent.

weeks of supply An inventory measure obtained by dividing the average aggregate inventory value by sales per week at cost.

Second, to some extent, managers can decide whether the aggregate inventory value is too low or too high by historical or industry comparison or by managerial judgment. However, a better performance measure would take demand into account. **Weeks of supply** is an inventory measure obtained by dividing the average aggregate inventory value by sales per week, again at cost. (In some low-inventory operations, days or even hours of supply are a better unit of time for measuring inventory.) The formula expressed using weeks is

$$\text{Weeks of supply} = \frac{\text{Average aggregate inventory value}}{\text{Weekly sales (at cost)}}$$

Although the numerator includes the value of all items (raw materials, WIP, and finished goods), the denominator represents only the finished goods sold—at cost rather than the sale price after markups or discounts. This cost is referred to as the *cost of goods sold*. (Within the supply chain, the weeks of supply can be calculated for specific items in a similar way, using the average inventory value for that item and the demand for that item.)

inventory turnover A measure of the rate at which inventory is consumed, obtained by dividing annual sales at cost by the average aggregate inventory value maintained during the year.

Third, **inventory turnover** (or *turns*) is an inventory measure obtained by dividing annual sales at cost by the average aggregate inventory value maintained during the year, or

$$\text{Inventory turnover} = \frac{\text{Annual sales (at cost)}}{\text{Average aggregate inventory value}}$$

TABLE 2.3 *Supply Chain Process Measures*

SUPPLIER RELATIONSHIP	ORDER FULFILLMENT	CUSTOMER RELATIONSHIP
• Percentage of suppliers' deliveries on time • Suppliers' lead times • Percentage of defects in purchased materials and services • Cost of purchased materials and services	• Percentage of incomplete orders shipped • Percentage of orders shipped on time • Time to fulfill the orders • Percentage of returned items or botched services • Cost to produce the item or service • Customer satisfaction with the order-fulfillment process	• Percentage of orders taken accurately • Time to complete the order placement process • Customer satisfaction with the order placement process • Availability of services • Customer's evaluation of firm's sustainability

The "best" or ideal inventory level cannot be determined easily, partly because inventory levels must support a firm's operations strategy. A good starting point is to benchmark the leading firms in an industry. See the Solved Problem at the end of this chapter for a detailed example of the three inventory measures.

PROCESS MEASURES

We discussed four core processes in Chapter 1, "Creating Value through Operations," namely, supplier relationship, order fulfillment, customer relationship, and new product design. These processes must be translated by supply chain managers into specific operating measures, as illustrated in Table 2.3. Collecting data on these measures allows managers to track changes in level or direction. In addition, statistical process control charts can be used to determine whether the changes are statistically significant, thereby prompting management's attention (see Chapter 7, "Quality and Process Improvement").

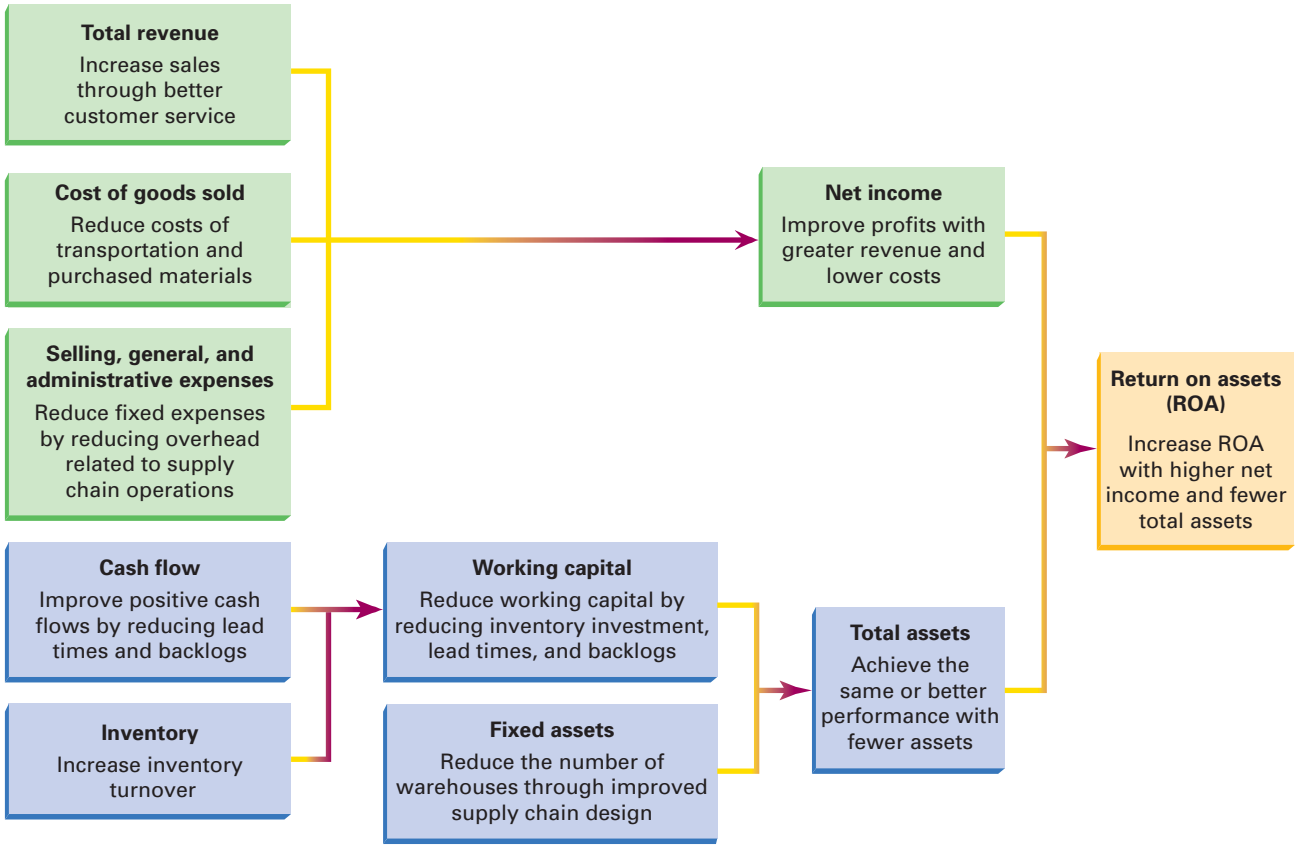
FINANCIAL MEASURES

How the supply chain is designed and managed has a huge financial impact on the firm. Inventory could be considered an investment, because it is created for future use. However, inventory is also a liability, in that it ties up funds that might be used more profitably elsewhere or it can hide operational problems. Figure 2.5 shows how supply chain decisions can affect financial measures.

TOTAL REVENUE. Supply chain performance measures related to time, which is a critical dimension of supply chain operations, have financial implications. As noted earlier in Table 2.3, timely availability of services and speedy delivery of goods to customers, for example, will increase total revenue because satisfied customers will buy more services and products from the firm.

COST OF GOODS SOLD. Being able to buy materials or services at a better price and transform them more efficiently into services or products improves a firm's cost of goods sold, and ultimately, its net income. These improvements also have an effect on the contribution margin, which is the difference between price and the variable costs to produce a service or good. Reducing the cost of order fulfillment, including purchased materials, production, logistics, and poor-quality costs, increases the contribution margin. Managers often use the contribution margin as one factor to decide which services or products to offer in the firm's portfolio.

FIGURE 2.5 *How Supply Chain Decisions Can Affect Financial Performance*



SELLING, GENERAL, AND ADMINISTRATIVE EXPENSES. Administration, distribution, and capital costs related to supply chains are often fixed costs. For example, designing a supply chain with minimal capital investment in warehouses can reduce overhead and depreciation expenses.

cash flow The difference between the flows of funds into and out of an organization over a period of time, including revenues, costs, and changes in assets and liabilities.

CASH FLOW. The supply chain design can improve positive net cash flows by focusing on reducing lead times and backlogs of orders. **Cash flow** is the difference between the flows of funds into and out of an organization over a period of time, including revenues, costs, and changes in assets and liabilities. The Internet brings another financial measure related to cash flows to the forefront: cash-to-cash is the time lag between paying for the services and materials needed to produce a service or product and receiving payment for it. The shorter the time lag, the better the cash flow position of the firm, because it needs less working capital. Ideally, a firm can build a *negative* cash-to-cash situation, which is possible when the customer pays the firm before it pays for the resources and materials needed to produce a service or product. Redesigning the customer relationship process can allow for payment by customers immediately when their orders are placed. The firm also must have supplier inventories on consignment, which allows it to pay for materials as it uses them.

WORKING CAPITAL. Inventory turns are reflected in another financial measure, working capital, which is money used to finance ongoing operations. Increasing inventory

turns reduces the working capital needed to finance inventories. Reductions in working capital can be accomplished by improving the customer relationship, order fulfillment, or supplier relationship processes. For example, reducing supplier lead times has the effect of reducing weeks of supply and increasing inventory turns. Matching the input and output flows of materials is easier because shorter-range, more reliable forecasts of demand can be used.

RETURN ON ASSETS. The design and management of the supply chain affects fixed investments, such as warehouses, and aggregate inventory investment, both of which are listed as assets on a firm's balance sheet. A related, important financial measure is return on assets (ROA), defined as net income divided by total assets. Consequently, reducing these investments or increasing net income through better cost management increases ROA. Techniques for reducing inventory, transportation, and operating costs related to resource usage and scheduling are discussed in the chapters to follow.

We now turn to a brief discussion of how four core processes are critically linked to supply chain decisions.

LO3 Distinguish between efficient and responsive supply chains and understand how each offers particular competitive benefits in different business settings.

SUPPLIER RELATIONSHIP PROCESS

The nature of the service or product determines the design requirements for the upstream supply chain. The supplier relationship process, which focuses on the interaction of the firm with upstream suppliers, includes five major nested processes: (1) sourcing, (2) design collaboration, (3) negotiation, (4) buying, and (5) information exchange. For many firms, these processes are the organizational responsibility of the purchasing or procurement function, which translates organizational needs into buying criteria; identifies, selects and qualifies suppliers; and manages the delivery of materials, equipment, or services. In doing so, purchasing must negotiate contracts, maintain information flows, and determine whether to buy locally.

SOURCING

The purchasing or procurement function is the eyes and ears of the organization in the supplier marketplace, continuously seeking better value from suppliers. Consequently, procurement is in a good position to select suppliers for the supply chain and to conduct certification programs.

total cost analysis Estimating all costs associated with sourcing a material or service in the supply chain, including materials, services such as transportation, administration, and inventory carrying costs.

green purchasing Using environmental criteria in purchasing decisions to favour suppliers (and inputs) with strong environmental management systems, performance, or certification.

SELECTION. Three criteria most often considered by firms selecting new suppliers are price, quality, and time. (The other three dimensions of customer value often have lower priority.) Because firms spend a large percentage of their total income on purchased items, finding suppliers that charge *low prices* is a key objective. However, as noted by Deming (see Chapter 7, "Quality and Process Improvement"), lowest price should not be the only purchasing criterion. The *quality* of a supplier's materials can dramatically affect the *total* cost of using that supplier. The hidden costs of poor quality can be high, particularly if defects are not detected until after considerable value has been added by subsequent operations. For a retailer, poor merchandise quality can mean loss of customer goodwill and future sales. Finally, shorter lead times and on-time *delivery* help the buying firm maintain acceptable customer service with less inventory. Thus, at a minimum, a **total cost analysis** is required, including materials, services such as transportation, administration, and inventory carrying costs.

Another criterion is becoming increasingly important in the selection of suppliers—environmental performance. Many firms are engaging in **green purchasing**, which

involves buying from firms with strong environmental management systems. This typically includes identifying, assessing, and managing the flow of environmental waste and finding ways to reduce it and minimize its impact on the environment. Suppliers are being asked to be environmentally conscious when designing and manufacturing their products, and claims such as *green*, *biodegradable*, *natural*, and *recycled* must be substantiated when bidding on a contract. This criterion has become increasingly important in the selection of suppliers over the past few years, particularly for consumer-oriented markets.

When faced with multiple criteria in the supplier selection problem, management can use a preference matrix. This technique collapses a variety of different criteria into a single measure, such as an overall supplier score. For example, a manager deciding between two suppliers of cleaning services might include multiple criteria such as flexibility, range of services, cost, and local reputation. Each potential supplier is scored on each criteria using the same scale, such as from 1 (worst possible) to 10 (best possible) or from 0 to 1. Next, each criteria is weighted according to its perceived importance, with the total of these weights typically equaling 100. Finally, the overall score for a supplier is the sum of the weighted scores (weight × score) for all the criteria.

$$\text{Overall score} = (w_1 s_1) + (w_2 s_2) + \ \ldots \ + (w_k s_k)$$

where

w_1 = weight for criterion 1
s_1 = score for criterion 1
k = number of criteria

The manager can compare the overall score or rating for different suppliers against one another or against a predetermined threshold (see Example 2.2).

EXAMPLE 2.2 *Using a Preference Matrix for Selecting Suppliers*

The management of Compton Electronics has done a total cost analysis for three international suppliers of keyboards. Compton also considers on-time delivery, consistent quality, and environmental stewardship in its selection process. Each criterion is given a weight (total of 100 points), and each supplier is given a score (1 = poor, 10 = excellent) on each criterion. The data are shown in the following table.

	WEIGHT	SCORE		
CRITERION		BELFAST	HONG KONG	THAILAND
Total Cost	25	5	8	9
On-Time Delivery	30	9	6	7
Consistent Quality	30	8	9	6
Environment	15	9	6	8

SOLUTION

The weighted score for each supplier is calculated by multiplying the weight by the score for each criterion and arriving at a total. For example, the Belfast overall score is

$$\text{Overall score} = (25 \times 5) + (30 \times 9) + (30 \times 8) + (15 \times 9) = 770$$

Similarly, the overall score for Hong Kong is 740, and for Thailand, 735. Consequently, Belfast is the preferred supplier.

Decision Point Even though Belfast had a higher total cost (i.e., its Total Cost score was lower, at 5), it significantly outperformed the other suppliers on the criteria Compton considered very important. Given the weights placed on the criteria, it is clear that Compton is willing to pay extra for better delivery performance, quality, and environmental stewardship.

SUPPLIER CERTIFICATION. Supplier certification programs verify that potential suppliers have the capability to provide the materials or services the buying firm requires. Certification typically involves site visits by a cross-functional team from the buying firm who do an in-depth evaluation of the supplier's capability to meet cost, quality, delivery, and flexibility targets from process and information system perspectives. Every aspect of producing the materials or services is explored through observation of the processes in action and review of documentation for completeness and accuracy. Once certified, the supplier can be used by purchasing without having to make background checks. Performance is regularly monitored, and the supplier may need recertification if performance declines.

An alternative approach is supplier certification audited by a third party, which is somewhat similar to a financial audit. Certifications such as ISO 14001 assess the environmental management systems of suppliers, and others such as SA8000 or Fairtrade evaluate working conditions or wages paid by suppliers such as coffee plantations for example. These certifications are increasingly being used in such industries as electronics, food, and clothing to assure retail buyers about the nature of supplier processes and practices.

DESIGN COLLABORATION

This process focuses on jointly designing new services or products with key suppliers; it facilitates concurrent engineering, discussed later in this chapter, by drawing key suppliers into the new service or product development process. This process seeks to eliminate costly delays and mistakes incurred when many suppliers design service packages or manufactured components in parallel.

early supplier involvement A program that includes suppliers in the design phase of a service or product.

presourcing A level of supplier involvement in which suppliers are selected early in a product's concept development stage and are given significant, if not total, responsibility for the design of certain components or systems of the product.

value analysis A systematic effort to reduce the cost or improve the performance of services or products, either purchased or produced.

An approach that many firms are using is called **early supplier involvement**, which leverages the expertise of suppliers during the design phase of a new service or product. Suppliers provide suggestions for design changes and materials choices that will result in more efficient operations and higher quality. Taken one step further, **presourcing** involves suppliers during a product's concept development stage, and they are given significant, if not total, responsibility for the design of certain components or systems of the product. This approach is described in the Managerial Practice about Boeing.

Firms can also improve performance by engaging in **value analysis,** which is a systematic effort to reduce the cost or improve the performance of services or products, either purchased or produced. It is an intensive examination of the services, materials, processes, information systems, and flows of material involved in the production of a service or an item. Benefits include reduced production, materials, and distribution costs; improved profit margins; and increased customer satisfaction. Because teams involving purchasing, production, and engineering personnel from both the firm and its major suppliers play a key role in value analysis, another potential benefit is increased employee morale. Value analysis should be part of continual efforts to improve the performance of the supply chain.

NEGOTIATION

The negotiation process focuses on obtaining an effective contract that meets the price, quality, and other requirements from suppliers. The orientation of a firm toward its suppliers will affect the negotiation and design collaboration processes.

competitive orientation A supplier relation that views negotiations between buyer and seller as a zero-sum game: whatever one side loses, the other side gains; short-term advantages are prized over long-term commitments.

COMPETITIVE ORIENTATION. The **competitive orientation** toward suppliers views negotiations between buyer and seller as a zero-sum game: whatever one side loses, the other side gains. Short-term advantages are prized over long-term commitments. The buyer may try to beat the supplier's price down to the lowest survival level or to push demand to high levels during boom times and order almost nothing during recessions. In contrast, the supplier presses for higher prices for specific levels of quality, customer service, and volume flexibility. Which party wins depends largely on who has the most clout.

Purchasing power determines the clout that a firm has. A firm has purchasing power when its purchasing volume represents a significant share of the supplier's sales or the purchased item or service is standardized and many substitutes are available. For example, Staples is the world's largest office products firm, with outlets in 27 countries and more than 300 stores in Canada. The buying power of this growing company has become enormous. Home Hardware, a lumber and home improvement cooperative with almost 1000 stores across Canada, aggregates the purchases of independent dealers to reduce the costs for materials and services for its members. Suppliers are willing to give Home Hardware lower prices because of the large-scale purchasing power.

cooperative orientation A supplier relation in which the buyer and seller are partners, each helping the other to achieve mutually beneficial objectives.

COOPERATIVE ORIENTATION. With the **cooperative orientation** to supplier relations, the buyer and seller are partners, each helping the other as much as possible. A cooperative orientation translates into a longer-term commitment, joint work on quality improvement, and support by the buyer of the supplier's managerial, technological, and capacity development. A cooperative orientation favours few suppliers of a particular item or service, with just one or two suppliers being the ideal number. As order volumes increase, the supplier gains repeatability, which helps movement toward high-volume operations at a low cost. When contracts are large and a long-term relationship is ensured, the supplier might even build a new facility and hire a new workforce, perhaps relocating close to the buyer's plant.

A cooperative orientation means that the buyer shares more information with the supplier on its future buying intentions. This forward visibility allows the supplier to make better, more reliable forecasts of future demand. The buyer visits the supplier's plants and cultivates cooperative attitudes. The buyer may even suggest ways to improve the supplier's operations. Similarly, the supplier may offer suggestions to the buyer to improve quality and reliability, or reduce costs. This close cooperation with the supplier could even mean that the buyer does not need to inspect incoming materials. It also could mean giving the supplier more latitude in specifications, involving the supplier more in designing parts, implementing cost-reduction ideas, and sharing in savings.

A cooperative orientation has opened the door for innovative arrangements with suppliers. One extreme example of such an arrangement is the Sharp plant, detailed at the beginning of Chapter 8, "Lean Systems," where suppliers are located on-site. This arrangement has several advantages. First, Sharp's capital investment is lower. Second, parts will arrive just before they are needed, so everyone's inventory costs will be low. Finally, improvements by suppliers in the assembly process will benefit all parties.

One advantage of reducing the number of suppliers in the supply chain is a reduction in the complexity of the procedures needed to support and manage them. However, reducing the number of suppliers for an item or service may have the disadvantage of increased risk of an interruption in supply, and less leverage to drive a good bargain in prices. The extreme situation, **sole sourcing**, is the awarding of a contract for an item or service to only one supplier. Doing so is particularly attractive if development and market risks are shared, as with key suppliers for Boeing's new 787 Dreamliner (see "Managerial Practice"); however, such an arrangement can amplify any supply problems that may arise over the life of the product. Managers can

sole sourcing The awarding of a contract for an item or service to only one supplier.

use a mixed strategy, such as a competitive approach for commodity-like supplies and a cooperative approach for complex, high-valued services and materials.

BUYING

The buying process relates to the actual purchase of the service or material from the supplier. This process includes the creation, management, and approval of purchase orders and determines the locus of control for purchasing decisions. Although not all purchasing opportunities involve the Internet, the emergence of the virtual marketplace has provided firms with many opportunities to improve their buying and information exchange processes. Here we discuss four approaches to e-purchasing, and close with the implications of choosing centralized versus decentralized buying.

electronic data interchange (EDI) A technology that enables the transmission of routine business documents having a standard format from computer to computer over telephone or direct leased lines.

ELECTRONIC DATA INTERCHANGE. The most used form of e-purchasing is **electronic data interchange** (**EDI**), a technology that enables the transmission of routine business documents having a standard format from computer to computer. Invoices, purchase orders, and payments are some of the routine documents that EDI can handle—it replaces the phone call or mailed document.

catalogue hubs Centralized electronic online catalogues that enable employees to place orders for preapproved items.

CATALOGUE HUBS. The costs of placing orders to suppliers, as well as the goods and services themselves, can be reduced through the use of **catalogue hubs**. Suppliers post their catalogue of items on the hub, and buyers select what they need and purchase them electronically. The hub connects the firm to potentially hundreds of suppliers through the Internet, saving the costs of EDI, which requires one-to-one connections to individual suppliers. Moreover, a buying firm can negotiate prices with specific suppliers for items such as office supplies, technical equipment, specialized items, services, or furniture. The catalogue that the buying firm's employees see consists only of the approved items and their negotiated prices. Employees use their computers or mobile devices to select the items they need, and the system generates the purchase orders, which are electronically dispatched to the suppliers.

exchange An electronic marketplace where buying firms and selling firms come together to do business.

EXCHANGES. An **exchange** is an electronic marketplace where buying and selling firms come together to do business. The exchange maintains relationships with buyers and sellers, making it easy to do business without the aspect of contract negotiations or other sorts of long-term conditions. Exchanges are often used for "spot" purchases, which are needed to satisfy an immediate need at the lowest possible cost. Commodity items such as oil, steel, or energy fit this category. However, exchanges can also be used for almost any item. For example, Marriott International, Hyatt Hotels, Fairmont Hotels, and others formed an exchange for the hospitality industry (www.avendra.com). This exchange allows hotels to do one-stop shopping for such items as soap, food, and equipment, rather than having to individually approach thousands of suppliers using faxes, telephones, and forms.

auction An extension of the exchange in which firms place competitive bids to buy something.

AUCTIONS. An extension of the exchange is the **auction**, where firms place competitive bids to buy something. For example, a site may be formed for a particular industry at which firms with excess capacity or materials can offer them for sale to the highest bidder. Bids can be either closed or open to the competition. Industries where auctions have value include steel, chemicals, and the home mortgage industry, where financial institutions can bid for mortgages.

An approach that has received considerable attention is the so-called *reverse auction*, in which suppliers bid for contracts with buyers. Each bid is posted, so suppliers can see how much lower their next bid must be to remain in the running for the contract. Each contract has an electronic prospectus that provides all the specifications,

MANAGERIAL PRACTICE

Building a Supply Chain for the Dreamliner

Suppose that you had the freedom to totally design the supply chain for one of the most highly anticipated airliners of modern times. The airliner, the Boeing 787 Dreamliner, is a super-efficient commercial airplane that can carry up to 290 passengers on routes as long as 15 750 kilometres, at cruising speeds of over 1000 kilometres per hour. It is to be constructed with carbon-fibre composite materials, which are lightweight and not susceptible to corrosion or fatigue like aluminum. This plane will be manufactured using 50 percent composite materials; Boeing used only 10 to 12 percent in the 777. Boeing's goal is to bring the most complex machine in mass production to market in just over four years, one-third less time than other projects. And when delivered to customers, the plane must meet demanding performance specifications, such as using 20% less fuel to reduce its carbon footprint and the environmental impact.

Boeing had two options for the design of the supply chain: (1) Produce about 50 percent of the plane in-house, including the wing and fuselage as in existing Boeing planes, and run the risk that production lead times would suffer because of capacity constraints or (2) outsource about 85 percent of the plane, essentially constructing only the vertical fin in-house, and manage the global suppliers responsible for design as well as production of major components. Boeing's senior managers chose the second option.

There are some good reasons for this choice. First, a number of big customers for the 787, such as India and Japan, require that significant portions of the aircraft must be manufactured in their countries. Using major contractors within those countries satisfies the requirement. Second, a shortage of high-quality engineering talent encourages further outsourcing. Third, the sheer complexity of the airplane makes it necessary to share the load. Boeing, even with all of its resources, could not build all of the components and pieces in one facility or region. Finally, work on the plane can proceed concurrently, rather than sequentially, thereby saving time and money. For example, the modular design of the plane allows Boeing to utilize flexible tooling to move planes through the factory much more quickly. Also, suppliers design and deliver the subsystems on a just-in-time basis where they are "snapped" together by a smaller number of factory workers in a matter of days rather than a month, the typical time for a plane of that complexity.

The first Boeing 787 Dreamliner takes shape in the final assembly plant in Everett, Washington. The new commercial airplane is assembled with major components produced worldwide.

Boeing chose to design its supply chain with 43 top-tier suppliers on three continents. Outsourcing so much responsibility requires a lot of managerial attention; you have to know what is going on in each factory at all times. As expected with something so complex, major glitches developed unexpectedly. The first Dreamliner to show up at Boeing's factory was missing tens of thousands of parts. Supplier problems ranged from language barriers to problems caused by some contractors who outsourced major portions of their assigned work and then experienced problems with their suppliers.

Cutting-edge design choices that simplify the supply chain and final assembly also presented difficult challenges. For example, the fuselage section—the big multi-part cylindrical barrel that encompasses the passenger seating area—was constructed as a single piece to eliminate 1500 aluminum sheets and over 40 000 fasteners. However, the first fuselage failed in company testing, causing Boeing to make more sections than planned and to re-examine quality and safety concerns. Software programs designed by a variety of manufacturers had trouble talking to one another, and the overall weight of the airplane was too high, especially the carbon-fibre wing. These and many other glitches caused a three-year delay in the deliveries of the first 787s. Finally, in September 2011, the first plane was delivered to a customer with great fanfare, and production capacity is being ramped up to 2.5 planes per month.

Will the advantages of collaboration on such a large scale outweigh the loss of logistical and design control? Moreover, will the $32 billion spent on developing the 787 provide Boeing a competitive advantage? Managers bet that these actions will pay off; by mid-2014, the firm had delivered over 145 Dreamliners, with outstanding orders for more than 1030 from over 50 customers.[3]

conditions, and other requirements that are non-negotiable. The only thing left to determine is the cost to the buyer, and savings can be dramatic.

Our discussion of these electronic approaches in purchasing should not leave the impression that cost is the only consideration in selecting a supplier. Exchanges and auctions are more useful for commodities, near-commodities, or infrequently needed items that require only short-term relationships with suppliers. The past two decades have taught us the lesson that suppliers should be thought of as partners when the needed supply is significant and steady over extended periods of time.

CENTRAL VERSUS LOCAL BUYING. When an organization has several facilities (e.g., stores, hospitals, or plants), management must decide whether to buy locally or centrally. This decision has implications for the control of supply chain flows.

Centralized buying has the advantage of increasing purchasing clout. Savings can be significant, often as much as 10 percent or more. Increased buying power can mean getting better service, ensuring long-term supply availability, or developing new supplier capability. Companies with overseas suppliers favour centralization because of the specialized skills (e.g., understanding of foreign languages and cultures) needed to buy from foreign sources. Buyers also need to understand international commercial and contract law regarding the transfer of goods and services. Another trend that favours centralization is the growth of computer-based information systems and the Internet, which give specialists at headquarters access to data previously available only at the local level.

Probably the biggest disadvantage of centralized buying is loss of control at the local level. When facilities or divisions are evaluated as profit or cost centres, centralized buying is undesirable for items unique to a particular facility. These items should be purchased locally whenever possible. The same holds for purchases that must be closely meshed with process schedules. Further, localized buying is an advantage when the firm has major facilities in foreign countries, because the managers there, often foreign nationals, have a much better understanding of the culture than staff would

at the home office. Also, centralized purchasing often contributes to longer lead times and another hierarchical level in the organization, which can slow decision making and hurt responsiveness.

Often, management must develop a mixed approach and leverage both centralized buying and local autonomy. For example, the corporate purchasing group at IBM negotiates contracts on a centralized basis only at the request of local plants. Then management at one of the facilities monitors the contract for all the participating plants. Alternatively, commodity-based purchases might be made by a centralized group, while specialized parts and services are bought at the local level in a decentralized fashion.

INFORMATION EXCHANGE

The information exchange process facilitates the exchange of pertinent operating information, such as forecasts, schedules, and inventory levels, between the firm and its suppliers. New technology in the form of radio frequency identification facilitates the flow of inventory information. Beyond inventory information, the exchange of forecasts and other demand-related data facilitates integrating activities such as vendor-managed inventories.

radio frequency identification (RFID) A method for identifying items through the use of radio signals from a tag attached to an item.

RADIO FREQUENCY IDENTIFICATION. An important requirement for the execution of order-fulfillment processes is accurate information regarding the quantity and location of inventories. **Radio frequency identification** (**RFID**) technology combines a transponder embedded in a tag, sometimes termed a "smart label," and a nearby reader to enable items to be automatically identified, tracked, and updated. Using either handheld or stationary readers, tags have capabilities to store, communicate, and receive data wirelessly. Such data might include general product information, such as a stock number, or unique item information, such as batch or serial number, production date, or other specific information.

Walmart and Gillette, among a number of large retailers, manufacturers, government agencies, and suppliers, are in the process of implementing RFID in their supply chains. In Walmart's case, RFID tags on cases and pallets can be read when inventory enters a stockroom and when those cases and pallets go to the retail floor. Walmart can use the data to draw conclusions about when to bring additional stock to the floor and to figure out if too much of a product has been ordered by a store and is sitting in the stockroom or in the distribution centre. The data could also help some 30 000 suppliers check inventory levels and sales. The use of RFID data can increase a supplier's service level to Walmart. Pilferage reduction is another major advantage of the RFID technology. Gillette is using RFID to reduce the amount of razor-blade theft, which amounts to as much as 30 percent.

Individual firms can use RFID within their own operations to simplify internal tracking and coordination. The larger potential gains from RFID tags come with their use in the supply chain. To be successful, all members of the supply chain, not just the firm pushing the project, must implement systems that tap into RFID information. This is particularly true for global operations, where data synchronization using industry standards is critical to ensure that accurate and consistent data is exchanged among supply chain partners located anywhere in the world.

vendor-managed inventories (VMI) An extreme application of the forward placement tactic that involves locating the inventories at customers' facilities.

VENDOR-MANAGED INVENTORIES. A tactic that employs an extreme case of forward placement is **vendor-managed inventories** (**VMI**), a system in which the supplier has access to the customer's inventory data and is responsible for maintaining the inventory level required by the customer. Service providers and manufacturers use VMI,

including such firms as AT&T, Roadway Express, Walmart, Dell, Westinghouse, and Bose. In some cases, although the inventory is on the customer's site, the supplier retains possession of the inventory until it is used.

Vendor-managed inventories have several key elements.

- *Collaborative effort*. For VMI to succeed, the customers must be willing to allow the supplier access to their inventory. The implication is that the supplier assumes an important administrative role in the management of the inventory. Thus, an atmosphere of trust and accountability is required.
- *Cost savings*. Suppliers and customers eliminate the need for excess inventory through better operational planning. VMI reduces costs by removing administrative and inventory costs. Order placement costs are also reduced.
- *Customer service*. The supplier is frequently on site and better understands the operations of the customer, improving response times and reducing stockouts.
- *Written agreement*. It is important that both parties fully understand the responsibilities of each partner. Areas such as billing procedures, forecast methods, and replenishment schedules should be clearly specified. Further, the responsibility for obsolete inventory resulting from forecast revisions and changes in contract lengths should be included.

continuous replenishment A VMI method in which the supplier monitors inventory levels at the customer and replenishes the stock as needed to avoid shortages.

If stock is replenished only as needed to avoid shortages, called **continuous replenishment**, inventories can be reduced while achieving greater efficiencies in warehousing and transportation.

LO4 Explain why managers might choose a supply chain strategy that includes outsourcing, offshoring or vertical integration.

ORDER FULFILLMENT PROCESS

The order fulfillment process produces and delivers the service or product to the firm's customers. There are four key nested processes: customer demand planning, supply planning, internal operations activities, and logistics.

CUSTOMER DEMAND PLANNING

Customer demand planning (CDP) facilitates the collaboration of a supplier and its customers to more accurately forecast customer requirements for a service or product. CDP is a business-planning process that enables sales teams (and customers) to develop demand forecasts as input to service-planning processes, production and inventory planning, and revenue planning. Forecasts must generally precede plans: it is not possible to make decisions on staffing levels, purchasing commitments, and inventory levels until forecasts are developed that give reasonably accurate views of demand over the forecasting time horizon. Chapter 11, "Managing Demand and Forecasting," provides more details on CDP and describes several practical tools.

SUPPLY PLANNING

The supply planning process takes the demand forecasts produced by CDP and the capacity available to generate a plan to meet the demand. This process is both critical for effective execution in the supply chain and very complex. For this reason we devote four later chapters to its important elements: capacity, inventory management, operations planning, and resource scheduling.

In a nutshell, the capacity of individual operations, facilities, and the broader supply chain must be assessed to determine if demand can be filled, as discussed in Chapter 5, "Capacity." For retailers or manufacturers, inventory offers one option

to have the product available ahead of a new product launch or in anticipation of future customer demand (see Chapter 6, "Inventory Management"). For example, a Nokia repair service facility must have enough components and materials on hand to fulfill its requirements for the repair of the various Nokia products under warranty. Alternatively, other services might use reservation systems, such as dental offices, or call in additional staff on overtime, such as UPS before the Christmas delivery rush. In Chapters 12 and 13 we show how firms schedule and plan productive resources to provide an appropriate level of supply for services or products.

INTERNAL OPERATIONS ACTIVITIES

The internal operations activities encompass all of the tasks required to deliver a product or service to a customer. These activities might be focused on addressing any of the competitive priorities, and might be done by either employees or customers. For example, a customer at a Loblaw grocery store in Canada has in effect ordered groceries, performed the work to actually find it in the inventory, and taken delivery when the groceries were paid for at the checkout cashier. However, Grocery Gateway in Toronto (www.grocerygateway.com) uses a webpage, which separates order placement (discussed in the next section under "Customer Relationship Process") from order fulfillment. Customers doing business on its webpage must accept a delay in receiving their groceries, a delay that Grocery Gateway seeks to minimize through effective management of its supply chain. Offering a new order-fulfillment process can have significant competitive implications, particularly in terms of changing the value offered to customers.

LOGISTICS

A key aspect of order fulfillment is the logistics process, which delivers the product or service to the customer. Five important decisions determine the design and implementation of logistics processes: degree of ownership, facility location, shipment mode, level of capacity, and amount of cross docking.

OWNERSHIP. The firm has the most control over the logistics process if it operates as a private carrier. Although this approach may help to better achieve some competitive priorities, the cost of equipment, labour, facilities, and maintenance could be high. The firm could instead leave the distribution to a third-party logistics provider (3PL). The integrated services offered by a 3PL include transportation, packaging, warehousing, and inventory management, among others.

FACILITY LOCATION. A critical decision affecting the effectiveness of supply chains is the location of facilities that serve as points of service, storage, or manufacture. Key decisions focus on whether facilities might be located in close proximity to suppliers or customers. As described at the beginning of this chapter, Nikon adjusted and expanded the location of upstream and downstream facilities. Later in Chapter 10, "Location and Layout", we explore these issues in greater detail.

SHIPMENT MODE. The five basic modes of transportation are truck, train, ship, pipeline, and airplane. The drivers for the selection should be the firm's competitive priorities. Trucks provide the greatest flexibility; transit times are short; and costs are usually the lowest for small quantities and short distances. Rail transportation can move large quantities cheaply; however, the transit times are long and often variable. Water transportation provides high capacity and low costs, and is necessary for overseas shipments of bulky items; however, the transit times are slow, and

then long-haul highway or rail transportation is often needed to get the product to its ultimate destination. Pipeline transportation is highly specialized and is used for liquids, gases, or solids in slurry form. Although it has limited geographical flexibility, transporting via pipeline requires no packaging, and the operating costs per kilometre are low. Finally, air transportation is the fastest and most costly mode per kilometre.

CAPACITY. The performance of a logistics process is directly linked to its capacity and variability of demand. Moreover, the ownership and shipment mode decisions are often intertwined, because the question of how much capacity is needed must be resolved. If ownership of the equipment and facilities is under consideration, capital costs as well as variable operating costs must be weighed against the costs of obtaining the logistics services from a supplier.

CROSS-DOCKING. Low-cost operations and delivery speed can be enhanced with a technique called **cross-docking**, which is the packing of products on incoming shipments so that they can be easily sorted at intermediate warehouses for outgoing shipments based on their final destinations. Items are carried from the incoming-vehicle docking point to the outgoing-vehicle docking point without being stored in inventory at the warehouse. For example, a truck from Montreal carrying shipments to customers in Ontario might arrive at a warehouse in Mississauga, where warehouse personnel unload its contents and reload them on trucks headed for destinations in neighbouring cities, such as Toronto, Hamilton, and London. Thus, inbound shipments must be tightly coordinated with outbound shipments for cross-docking to work. The benefits of cross-docking include reductions in inventory investment, storage space requirements, handling costs, and lead times, as well as increased inventory turnover and accelerated cash flow.

cross-docking The packing of products on incoming shipments so that they can be easily sorted at intermediate warehouses and immediately transferred for outgoing shipment based on their final destinations.

LO5 measure performance of supply chains.

CUSTOMER RELATIONSHIP PROCESS

The customer relationship process addresses the interface between the firm and its customers downstream in the supply chain. We use the term customer to refer to an organization or individual the firm is trying to serve, which might be a consumer or a business. The purpose of the customer relationship process is to identify, attract, and build relationships with customers and to facilitate the transmission and tracking of orders.

ORDER PLACEMENT PROCESS

The **order placement process** involves the activities required to register the need for a product or service and to confirm the acceptance of the order. These activities are initiated by the customer but consummated by the firm producing the product or service. The Internet has enabled firms to re-engineer their order placement process to benefit both the customer and the firm. Some companies, however, have been able to use the Internet to eliminate certain elements of their supply chains by substituting information for inventories. Other firms have used it to reduce the transaction costs in their supply chains. Still others have used it to expand the reach and responsiveness of the supply chain. The Internet provides the following advantages for a firm's order placement process.

order placement process The activities required to register the need for a product or service and to confirm the acceptance of the order.

- *Cost reduction.* Using the Internet can reduce the costs of processing orders because it allows for greater participation by the customer. Customers can select the products or services they want and place an order with the firm without actually talking to anyone.

- *Revenue flow increase.* A firm's webpage can allow customers to enter billing information during the order placement process, and suggest related goods or services. This approach also reduces the time lags for payment collection.
- *Global access.* The Internet also allows firms to accept orders 24 hours a day from virtually any location, potentially reducing the time it takes to satisfy a customer.
- *Pricing flexibility.* Firms with their products and services posted on the Web can easily change prices as the need arises. For example, online bookstores can suggest to customers items that are overstocked, or provide time-limited discounts.

CUSTOMER SERVICE

The customer service process helps customers with answers to questions regarding the service or product, resolves problems, and, in general, provides information to assist customers. It is an important point of contact between the firm and its customers, who may judge the firm on the basis of their experiences with this process. The age-old trade-off between cost and quality, however, enters the picture, especially for call centres. In an effort to reduce the cost of their customer service process, many firms have opted to replace human service agents with automated systems, which often require customers to wade through an exhausting sequence of options that sometimes only lead to frustration. Other firms are using Verbots®, or "verbal robots," which are supported by sophisticated artificial intelligence. They have personalities, ask and respond to questions, and in some cases are almost indistinguishable from humans over the phone. Nonetheless, most customers and others seeking information about a service or product prefer interaction with a real person.

Consequently, in consideration for the cost involved, many companies have expanded their supply chain by outsourcing the customer service process to an offshore site where labour costs are low. In this regard, India has responded in a big way to the international need for low-cost call centres. For example, you might have a problem with your Hewlett-Packard ink-jet printer and solve that problem by talking to a technician in Bangalore, India. Of course, the big risk in outsourcing the customer service process, or a part of it, is that the firm loses some control over a process that has direct interface with its customers. This consideration should be carefully weighed in the final analysis.

LO6 describe the major causes of supply chain dynamics, their effects, and options to improve performance.

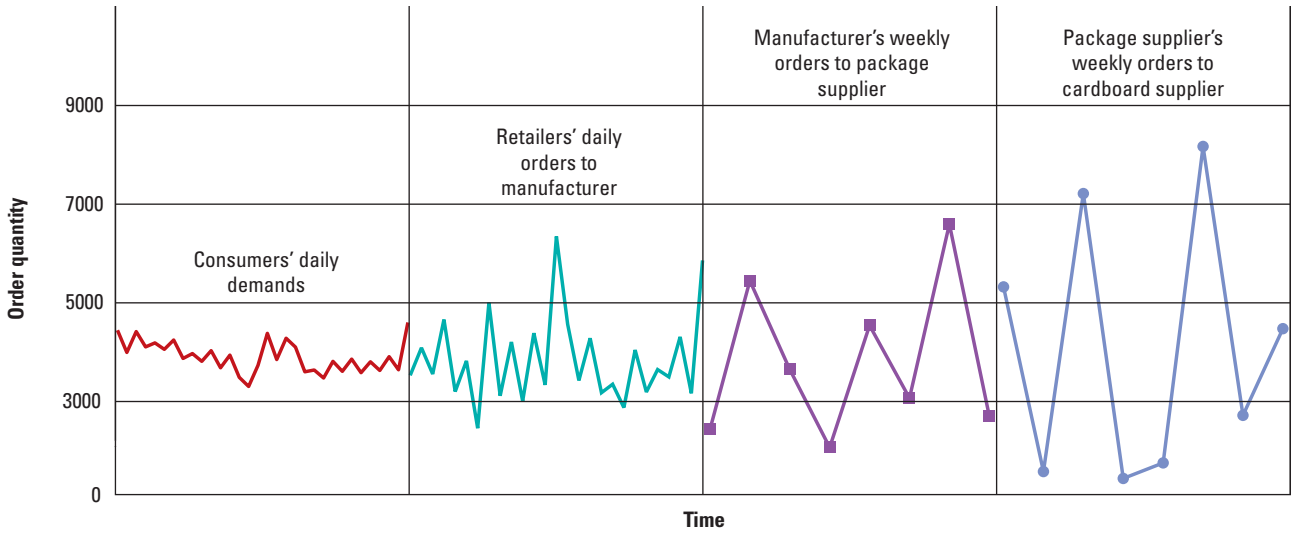
SUPPLY CHAIN DYNAMICS

Supply chains often involve linkages among many firms and the interactions between them. Each firm in a supply chain depends on other firms for services, materials, or the information needed to supply its immediate external customer in the chain. It is not surprising that the actions of upstream suppliers, such as shortages, can affect the downstream customers. However, these dynamics can flow the other direction too—the actions of customers can dramatically affect suppliers, even several tiers away!

bullwhip effect The phenomenon in supply chains whereby ordering patterns show increasing variance as you move upstream in the chain.

As you examine the pattern of orders of firms in a supply chain, you will frequently see the variability in order quantities increase as you proceed upstream. This increase in variability is referred to as the **bullwhip effect**, which gets its name from the action of a bullwhip—the handle of the whip initiates the action; however, the tip of the whip experiences the wildest action. Inaccurate information or the slightest change in customer demands can ripple through the entire chain, with

FIGURE 2.6 *Supply Chain Dynamics for Facial Tissue*



each member receiving more variability in demands from the member immediately downstream.

The bullwhip effect in a supply chain for facial tissue is depicted in Figure 2.6. The retailers' orders to the manufacturer exhibit more variability than the actual demands from the consumers of the facial tissue because shipments to a retailer occur much less frequently than a customer buying individual packages. The manufacturer's orders to the package supplier have more variability than the retailers' orders. Finally, the package supplier's orders to the cardboard supplier have the most variability. Because supply patterns do not match demand patterns, inventories accumulate in some firms and shortages occur in others. The firms with too much inventory stop ordering, and those that have shortages place expedited orders. The culprits are unexpected changes in demands or supplies that are based on a number of causes.

EXTERNAL CAUSES

A firm has the least amount of control over its external customers and suppliers, who can periodically cause disruptions. Typical disruptions include the following:

- *Volume changes*. Customers may change the quantity of the service or product they had ordered for a specific date or unexpectedly demand more of a standard service or product. If the market demands short lead times, the firm needs a quick reaction from its suppliers.
- *Service and product mix changes*. Customers may change the mix of items in an order and cause a ripple effect throughout the supply chain. For example, a major retailer may change the mix of Kleenex™ facial tissues throughout the year. During summer, 60% might be Everyday tissues, 35% Ultra Soft, and 5% Cool Touch. As winter approaches, the product orders might shift to 30% Everyday tissues, 60% Ultra Soft, and 10% Cool Touch. This decision changes the production schedule at Kimberly-Clark, the manufacturer of both brands. In addition, companies that make packaging for each product (tier 1 suppliers), as well as packaging raw materials (tier 2 suppliers), must change their schedules.

- *Late deliveries*. Late deliveries of materials or delays in essential services can force a firm to switch its schedule from production of one product model to another. Suppliers that provide product-specific materials then have their schedules disrupted. For example, the Kimberly-Clark plant may find that the aloe supplier for its Cool Touch tissues could not deliver on time. To avoid shutting down the production line, which is a very expensive action, the firm may decide to switch to producing Ultra Soft tissues. Suddenly, the demand for Ultra Soft packaging increases.
- *Underfilled shipments*. Suppliers that send partial shipments do so because of disruptions at their own plants. The effects of underfilled shipments are similar to those of late shipments unless they contain enough to allow the firm to operate until the next shipment.

INTERNAL CAUSES

A famous line from a Pogo cartoon is "We have seen the enemy, and he is us!"[4] Unfortunately, this statement is true for many firms when it comes to disruptions in the supply chain. Typical internal disruptions that cause increased variability include the following:

- *Internally generated shortages*. There may be a shortage of parts manufactured by a firm because of machine breakdowns or inexperienced workers—all sources of variation discussed in Chapter 5, "Capacity." A labour shortage, possibly caused by absenteeism, has a similar effect.
- *Order Batching*. Suppliers may offer a quantity discount, which gives an incentive to firms to purchase large quantities of an item less frequently, thereby raising the variability in orders to the supplier. Order batching may also result in transportation economies; larger orders may enable full-truckload shipments and thus create more variability.
- *Engineering changes*. Changes to the design of services or products can have a direct impact on suppliers. For example, changing cable TV feed lines to fibre-optic technology increases the benefits to the cable company's customers but affects the demand for cable.
- *New service or product introductions*. A firm decides on the number of introductions, as well as their timing, and hence introduces variability in the supply chain. New services or products may even require a new supply chain or the addition of new members to an existing supply chain.
- *Service or product promotions*. A common practice of firms producing standardized products or services is to use occasional price discounts to promote sales. This has the effect of creating a spike in demand followed by a trough, which is felt throughout the supply chain.
- *Information errors*. Demand forecast errors could cause a firm to order too many, or too few, services and materials. Also, forecast errors can result in expedited orders that force suppliers to react more quickly to avoid shortages in the supply chain. In addition, errors in the physical count of items in stock can cause shortages (leading to panic purchases) or too much inventory (leading to a slowdown in purchases).

Many disruptions are simply caused by ineffective coordination in the supply chain because so many firms and separate operations are involved. It is therefore unrealistic to think that all disruptions can be eliminated. As firms move toward

more integrated supply chains, described earlier in this chapter, it is possible to reduce the number of disruptions and minimize the impact of those that cannot be eliminated.

LEVERS FOR IMPROVED SUPPLY CHAIN PERFORMANCE

While supply chain dynamics can cause many problems, managers also have several options that they can pursue to improve performance.[5]

- *Sharing data.* One source of dynamics in supply chains is the lack of visibility of end-user demand by suppliers upstream in the supply chain. To facilitate planning at all levels in the supply chain, point-of-sale (POS) data, which records actual customer purchases of the final service or product, can be shared with all suppliers. RFID can also be used to track quantities of inventory throughout the supply chain.
- *Collaborative activities.* Working closely with customers and suppliers in customer demand planning (CDP) and environmental health and safety programs, as well as the design collaboration process, improves information flows, improves environmental stewardship, and reduces surprises from demand spikes due to promotions or supply hangups because of poorly designed services or products.
- *Reduce replenishment lead times.* Improving internal processes and working with suppliers to reduce lead times allows the firm to wait longer before reacting to a change in demand levels, mitigating the bullwhip effect. In addition, shorter lead times lead to smaller pipeline inventories.
- *Reduce order lot sizes.* Working on ways to reduce the costs associated with ordering, transporting, and receiving inventory throughout the supply chain will reduce order lot sizes and thereby decrease the amount of fluctuation in the size of orders in the supply chain.
- *Ration short supplies.* When a shortage exists, customers sometimes artificially inflate their orders to protect themselves, only to cancel them later when the shortage is relieved. To counteract this behaviour, suppliers can ration short supplies to customers on the basis of their past sales, rather than their current orders.
- *Use everyday low pricing (EDLP).* Promotional or discount pricing encourages spikes in demand. Using a stable pricing program such as EDLP, as is done by Walmart, discourages customers from buying excess stock at discounted prices, so they can offer price promotions, a practice called *forward buying*. EDLP levels the demand.
- *Be cooperative and trustworthy (to a point).* Being cooperative in solving supply issues and providing information that can be trusted serves to reduce costs for all members of the supply chain and mitigates environmental problems and the deleterious effects of supply chain dynamics. However, it is critical to protect core processes and technologies.

Integrated supply chains are powerful tools for achieving competitiveness along many performance measures. Currently, concerns about the environment and treatment of workers are prompting supply chain managers to take a careful look at their own operations and those of distant suppliers. In Chapter 3, "(More) Sustainable Supply Chains and Humanitarian Logistics", we take a look at how managers are examining and translating environmental and social concerns into better supply chain practices.

EQUATION SUMMARY

1. Make-or-buy break-even quantity: $Q = \dfrac{F_m - F_b}{c_b - c_m}$

2. Average aggregate inventory value $= (N_a c_a) + (N_b c_b) + \ \ldots \ + (N_n c_n)$

3. Weeks of supply $= \dfrac{\text{Average aggregate inventory value}}{\text{Weekly sales (at cost)}}$

4. Inventory turnover $= \dfrac{\text{Annual sales (at cost)}}{\text{Average aggregate inventory value}}$

5. Overall score $= (w_1 s_1) + (w_2 s_2) + \ \ldots \ + (w_k s_k)$

CHAPTER HIGHLIGHTS

- A supply chain is a set of linkages among suppliers of materials and services that spans the transformation of raw materials into services and products that are delivered to customers.
- A basic purpose of supply chain management is to control inventory by managing the flows of materials. Three aggregate categories of inventories are raw materials, work-in-process, and finished goods. Both inventory pooling and forward placement of inventories can reduce the total inventory in the supply chain.
- Supply chain performance is tracked with inventory measures such as aggregate inventory level, weeks of supply, and inventory turnover. Supply chain process measures include broader measures that assess performance related to three core processes, that is, supplier relationship, order fulfillment, and customer relationship. Outcomes from these core processes drive financial measures such as total assets, return on assets, working capital, cost of goods sold, and cash flow.
- When sourcing, firms can select suppliers using multiple criteria related to their competitive priorities for creating customer value. Verification of supplier capabilities relies on either a firm's own staff or an external audit and certification by a third party. Early supplier involvement in new service or product development and presourcing can yield reduced costs, higher quality, and better employee morale.
- Buyers can take two approaches in dealing with their suppliers. The competitive orientation pits supplier against supplier in an effort to get the buyer's business. Alternatively, the cooperative orientation seeks to make long-term commitments to a small number of suppliers, with advantages accruing to both parties. The orientation chosen should be aligned with the firm's operations strategy to create customer value.
- The Internet is changing the way many firms handle purchasing. Internet-based catalogue hubs, exchanges, and auctions are recent innovations.
- The customer relationship process is continuing to change using technology. Order placement can be re-engineered to allow more customer involvement, to lower labour costs, to enable remaining open 24/7, and to enable the use of pricing as a means to influence demand to accommodate product shortages. Customer service also can be automated or moved offshore to call centres in developing economies.
- Because supply chains consist of many independent firms linked to other firms, disruptions with customers (i.e., downstream) can cascade upstream to suppliers, growing ever larger with each upstream tier in the supply chain. Both internal and external sources of variability contribute to this problem through a process termed the *bullwhip effect*.
- Efficient supply chains are designed to coordinate the flows of materials and services so as to minimize inventories and maximize the efficiency of the firms in the supply chain. Responsive supply chains are designed to react quickly to market demand through judicious use of inventories and flexible capacity. Each can be effective, if matched correctly with service or product characteristics.
- Other strategic decisions for supply chain managers include vertical integration, outsourcing, and offshoring. Competitive priorities, combined with the firm's operational strategy, guide managers as they balance benefits and risks, such as the potential loss of technological advantages to former suppliers.

SOLVED PROBLEM 1

A firm's cost of goods sold last year was $3 410 000, and the firm operates 52 weeks per year. It carries seven items in inventory: three raw materials, two work-in-process items, and two finished goods. The following table contains last year's average inventory level for each item, along with its value.

CATEGORY	PART NUMBER	AVERAGE LEVEL	UNIT VALUE
Raw materials	1	15 000	$ 3
	2	2 500	5
	3	3 000	1
Work-in-process	4	5 000	14
	5	4 000	18
Finished goods	6	2 000	48
	7	1 000	62

a. What is the average aggregate inventory value?

b. How many weeks of supply does the firm maintain?

c. What was the inventory turnover last year?

SOLUTION

a.

PART NUMBER	AVERAGE LEVEL		UNIT VALUE		TOTAL VALUE
1	15 000	×	$ 3	=	$ 45 000
2	2 500	×	$ 5	=	$ 12 500
3	3 000	×	$ 1	=	$ 3 000
4	5 000	×	$14	=	$ 70 000
5	4 000	×	$18	=	$ 72 000
6	2 000	×	$48	=	$ 96 000
7	1 000	×	$62	=	$ 62 000
	Average aggregate inventory value			=	$360 500

b. Average weekly sales at cost = $3 410 000/52 weeks = $65 577/week

$$\text{Weeks of supply} = \frac{\text{Average aggregate inventory value}}{\text{Weekly sales (at cost)}} = \frac{\$360\,500}{\$65\,577} = 5.5 \text{ weeks}$$

c. $$\text{Inventory turnover} = \frac{\text{Annual sales (at cost)}}{\text{Average aggregate inventory value}} = \frac{\$3\,410\,000}{\$360\,500} = 9.5 \text{ turns}$$

SOLVED PROBLEM 2

ABC Electric Repair wants to select a supplier based on total annual cost, consistent quality, and delivery speed. The following table shows the weights that management assigned to each criterion (total of 100 points) and the scores assigned to each supplier (Excellent = 5, Poor = 1).

	WEIGHT	SCORE	
CRITERION		KRAMER	SUNRISE
Total Cost	30	4	5
On-Time Delivery	40	3	4
Consistent Quality	30	5	3

Which supplier should ABC select, given these criteria and scores?

SOLUTION

Using the preference matrix approach, the weighted scores for each supplier are

$$\textit{Kramer}: WS = (30 \times 4) + (40 \times 3) + (30 \times 5) = 390$$
$$\textit{Sunrise}: WS = (30 \times 5) + (40 \times 4) + (30 \times 3) = 400$$

Based on the weighted scores, ABC should select Sunrise even though delivery speed performance would be better with Kramer.

PROBLEMS

Additional student problems and supporting software are available on the companion website for study preparation, in-depth analysis, and assignments.

1. EBI Solar uses a high-tech process to turn silicon wafers into tiny solar panels. These efficient and inexpensive panels are used to power low-energy hand-held electronic devices. Last year, EBI Solar turned their inventory 4.5 times and had a cost of goods sold of $2.5 million. Assuming 52 business weeks per year,
   a. Express last year's average inventory in weeks of supply.
   b. After several supply chain improvement initiatives, inventory investment has dropped across all inventory categories. While EBI's cost of goods sold is not expected to change from last year's level, the value of raw materials has dropped to $100 500, work-in-process to $25 800, and finished goods to $16 200. Assuming 52 business weeks per year, express EBI's current total inventory level in weeks of supply and inventory turns.
2. Roll-away Corporation supplies alloy ball bearings to equipment manufacturers across Western Canada. Because of its specialized manufacturing process, considerable work-in-process and raw materials are needed. The current inventory levels are $2 470 000 and $1 566 000, respectively. In addition, finished goods inventory is $1 200 000 and sales (at cost) for the current year are expected to be about $48 million. Express total inventory as
   a. Weeks of supply
   b. Inventory turns
3. Sterling, Inc. operates 52 weeks per year, and its cost of goods sold last year was $6 500 000. The firm carries eight items in inventory: four raw materials, two work-in-process items, and two finished goods. Table 2.4 shows last year's average inventory levels for these items, along with their unit values.
   a. What is the average aggregate inventory value?
   b. How many weeks of supply does the firm have?
   c. What was the inventory turnover last year?

TABLE 2.4 *Inventory Items*

CATEGORY	PART NUMBER	AVERAGE INVENTORY UNITS	VALUE PER UNIT
Raw materials	RM-1	20 000	$ 1
	RM-2	5 000	5
	RM-3	3 000	6
	RM-4	1 000	8
Work-in-process	WIP-1	6 000	10
	WIP-2	8 000	12
Finished goods	FG-1	1 000	65
	FG-2	500	88

4. One product line has 10 turns per year and an annual sales volume (at cost) of $985 000. How much inventory is being held, on average?
5. The following data were collected for a retailer:

Cost of goods sold	$3 500 000
Gross profit	$ 700 000
Operating costs	$ 500 000
Operating profit	$ 200 000
Total inventory	$1 200 000
Fixed assets	$ 750 000
Long-term debt	$ 300 000

Assuming 52 business weeks per year, express total inventory as

a. Weeks of supply
b. Inventory turns

6. A large global automobile manufacturer is considering outsourcing the manufacturing of a solenoid used in the transmission of its SUVs. The company estimates that annual fixed costs of manufacturing the part in-house, which include equipment, maintenance, and management, amount to $6 million. The variable costs of labour and material are $5.00 per unit. The company has an offer from a major subcontractor to produce the part for $8.00 per unit. However, the subcontractor wants the company to share in the costs of the equipment. The automobile company estimates that the total cost would be $4 million, which also includes management oversight for the new supply contact.

a. How many solenoids would the automobile company need per year to make the in-house option least costly?
b. What other factors, besides costs, should the automobile company consider before revising its supply chain for SUVs?

7. At the BlueFin Bank corporate headquarters, management was discussing the potential of outsourcing the processing of credit card transactions to DataEase, an international provider of banking operational services. Processing of the transactions at BlueFin has been a costly element of the annual profit-and-loss statement, and the continual investment in equipment to keep up to date has been draining capital reserves. Based upon initial study and negotiations, DataEase will charge $0.02 more per transaction than BlueFin's cost per transaction, and DataEase will want $12 million per year to cover equipment and overhead costs associated with the contract. BlueFin has yet to develop an estimate for the annual overhead and fixed costs associated with processing the transactions. These costs include supervision, administrative support, maintenance, equipment depreciation, and overhead. If BlueFin must process 20 million transactions per year, how high must those fixed costs be before it would pay to use DataEase?
8. The Bennet Company purchases one of its essential raw materials from three suppliers. Bennet's current policy is to distribute purchases equally among the three. The owner's son, Ben Bennet, has recently joined the family firm. He proposes that these suppliers be rated (higher numbers indicate better performance) on six performance criteria weighted as shown in the table. A total score hurdle of 0.60 is proposed to screen suppliers. The firm's purchasing policy would be revised to order raw materials from suppliers with performance scores greater than the total score hurdle, in proportion to their performance rating scores.

	WEIGHT	RATING		
CRITERION		*SUPPLIER A*	*SUPPLIER B*	*SUPPLIER C*
1. Price	0.2	0.6	0.5	0.9
2. Quality	0.2	0.6	0.4	0.8
3. Delivery	0.3	0.6	0.3	0.8
4. Production facilities	0.1	0.5	0.9	0.6
5. Environmental protection	0.1	0.7	0.8	0.6
6. Financial position	0.1	0.9	0.9	0.7

a. Use a preference matrix to calculate the total weighted score for each supplier.
b. Which supplier(s) survived the total score hurdle? Under the proposed policy, what proportion of orders would each supplier receive?
c. What advantages does the proposed policy have over the current policy?

9. Beagle Clothiers uses a weighted score for the evaluation and selection of its suppliers of trendy fashion garments. To accommodate changes in quantity and timing, each supplier is rated on a 10-point scale (10 = highest) for four different criteria: price, quality, delivery, and flexibility. Because of the volatility of the business in which Beagle operates, flexibility is given twice the weight of each of the other three criteria, which are equally weighted. The table below shows the scores for three potential suppliers for the four performance criteria. Based on the weighted score, which supplier should be selected?

	WEIGHT	RATING		
CRITERION		*ACTIVEWEAR*	*BRAVO*	*CHARISMA*
1. Price	0.2	8	6	6
2. Quality	0.2	9	7	7
3. Delivery	0.2	7	9	6
4. Flexibility	0.4	5	8	9

NOTES FOR CHAPTER

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Companion Website

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