Supply Chain Management

CHAPTER OUTLINE

Alaska Airlines

10 OM STRATEGY DECISIONS

- Design of Goods and Services
- Managing Quality
- Process Strategy
- Location Strategies
- Layout Strategies
- Human Resources
- *Supply Chain Management*
- Inventory Management
- Scheduling
- Maintenance

Darden's Supply Chain Yields a Competitive Edge

D arden Restaurants, Inc., is one of the largest publicly traded casual dining restaurant companies in the world with $6.3 billion in annual sales. It serves over 320 million meals annually from more than 1,500 restaurants in North America. Its well-known flagship brand—Olive Garden—generates sales of $3.6 billion annually. Darden's other brands include Bahama Breeze, Seasons 52, The Capital Grille, Eddie V's, Yard House, and LongHorn Steak-house. The firm employs more than 150,000 people and is the 33rd largest employer in the U.S.

"Operations is typically thought of as an execution of strategy. For us it is the strategy," Darden's former chairman, Joe R. Lee, stated.

In the restaurant business, a winning strategy requires a winning supply chain. Nothing is more important than sourcing and delivering healthy, high-quality food; and there are very few

Qualifying Worldwide Sources: Part of Darden's supply chain begins with a crab harvest in the frigid waters off the coast of Alaska. But long before a supplier is qualified to sell to Darden, a total quality team is appointed. The team provides guidance, assistance, support, and training to the suppliers to ensure that overall objectives are understood and desired results accomplished.

Aquaculture Certification: Shrimp in this Asian plant are certified to ensure traceability. The focus is on quality control certified by the Aquaculture Certification Council, of which Darden is a member. Farming and inspection practices yield safe and wholesome shrimp.
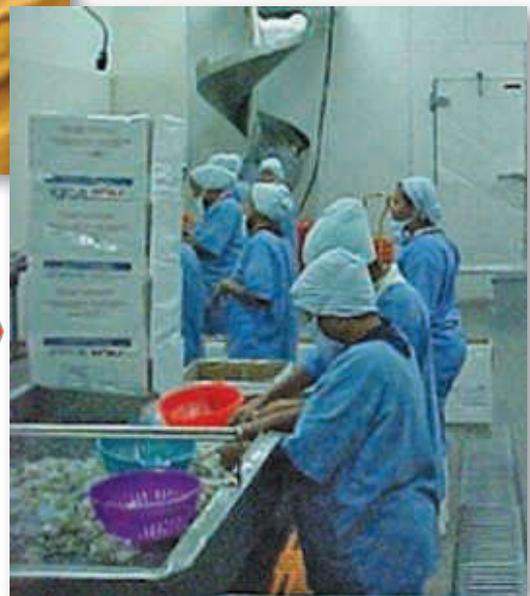
The Supply Chain's Strategic Importance

Like Darden, most firms spend a huge portion of their sales dollars on purchases. Because an increasing percentage of an organization's costs are determined by purchasing, relationships with suppliers are increasingly integrated and long term. Combined efforts that improve innovation, speed design, and reduce costs are common. Such efforts, when part of a corporate-wide strategy, can dramatically improve all partners' competitiveness. This integrated focus places added emphasis on managing supplier relationships.

Supply chain management

The coordination of all supply chain activities involved in enhancing customer value.

 Supply chain management describes the coordination of all supply chain activities, starting with raw materials and ending with a satisfied customer. Thus, a supply chain includes suppliers; manufacturers and/or service providers; and distributors, wholesalers, and/or retailers who deliver the product and/or service to the final customer. Figure 11.1 provides an example of the breadth of links and activities that a supply chain may cover.

 The objective of supply chain management is to structure the supply chain to maximize its competitive advantage and benefits to the ultimate consumer. Just as with championship teams, a central feature of successful supply chains is members acting in ways that benefit the team (the supply chain).

Figure 11.1

A Supply Chain for Beer

The supply chain includes all the interactions among suppliers, manufacturers, distributors, and customers. A well-functioning supply chain has information flowing between all partners. The chain includes transportation, scheduling information, cash and credit transfers, as well as ideas, designs, and material transfers. Even can and bottle manufacturers have their own tiers of suppliers providing components such as lids, labels, packing containers, etc. (Costs are approximate and include substantial taxes.)

OM in Action — A Rose Is a Rose, but Only If It Is Fresh

Supply chains for food and flowers must be fast, and they must be good. When the food supply chain has a problem, the best that can happen is the customer does not get fed on time; the worst that happens is the customer gets food poisoning and dies. In the floral industry, the timing and temperature are also critical. Indeed, flowers are the most perishable agricultural item—even more so than fish. Flowers not only need to move fast, but they must also be kept cool, at a constant temperature of 33 to 37 degrees. And they must be provided preservative-treated water while in transit. Roses are especially delicate, fragile, and perishable.

Eighty percent of the roses sold in the U.S. market arrive by air from rural Colombia and Ecuador. Roses move through this supply chain via an intricate but fast transportation network. This network stretches from growers who cut, grade, bundle, pack, and ship; to importers who make the deal; to the U.S. Department of Agriculture personnel who quarantine and inspect for insects, diseases, and parasites; to U.S. Customs agents who inspect

and approve; to facilitators who provide clearance and labeling; to wholesalers who distribute; to retailers who arrange and sell; and finally to the customer. Each and every minute the product is deteriorating. The time and temperature sensitivity of perishables like roses requires sophistication and refined standards in the supply chain. Success yields quality and low losses. After all, when it's Valentine's Day, what good is a shipment of roses that arrives wilted or late? This is a difficult supply chain; only an excellent one will get the job done.

Sources: NPR (Feb. 13, 2015); *Supply Chain 24/7* (Feb. 13, 2014); and *The Star-Ledger* (Feb. 6, 2011).

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cost or rapid response demand different things from a supply chain than a strategy of differentiation. For instance, a low-cost strategy, as Table 11.2 indicates, requires suppliers be selected based primarily on cost. Such suppliers should have the ability to design low-cost products that meet the functional requirements, minimize inventory, and drive down lead times. However, if you want roses that are fresh, build a supply chain that focuses on response (see the *OM in Action* box "A Rose Is a Rose, but Only If It Is Fresh").

Firms must achieve integration of strategy up and down the supply chain. And they must expect that strategy to be different for different products and to change as products move through their life cycle. Darden Restaurants, as noted in the opening *Global Company Profile*, has mastered worldwide product and service complexity by segmenting its supply chain and at the same time integrating four unique supply chains into its overall strategy.

VIDEO 11.1
Darden's Global Supply Chain

Sourcing Issues: Make-or-Buy and Outsourcing

As suggested in Table 11.2, a firm needs to determine strategically how to design the supply chain. However, prior to embarking on supply chain design, operations managers must first consider the "make-or-buy" and outsourcing decisions.

TABLE 11.2	How Corporate Strategy Impacts Supply Chain Decisions*		
	LOW-COST STRATEGY	**RESPONSE STRATEGY**	**DIFFERENTIATION STRATEGY**
Primary supplier selection criteria	• Cost	• Capacity • Speed • Flexibility	• Product development skills • Willing to share information • Jointly and rapidly develop products
Supply chain inventory	• Minimize inventory to hold down costs	• Use buffer stocks to ensure speedy supply	• Minimize inventory to avoid product obsolescence
Distribution network	• Inexpensive transportation • Sell through discount distributors/retailers	• Fast transportation • Provide premium customer service	• Gather and communicate market research data • Knowledgeable sales staff
Product design characteristics	• Maximize performance • Minimize cost	• Low setup time • Rapid production ramp-up	• Modular design to aid product differentiation

*See related table and discussion in Marshall L. Fisher, "What Is the Right Supply Chain for Your Product?" *Harvard Business Review* (March–April 1997): 105.

Make-or-Buy Decisions

A wholesaler or retailer buys everything that it sells; a manufacturing operation hardly ever does. Manufacturers, restaurants, and assemblers of products buy components and subassemblies that go into final products. As we saw in Chapter 5, choosing products and services that can be advantageously obtained *externally* as opposed to produced *internally* is known as the make-or-buy decision. Supply chain personnel evaluate alternative suppliers and provide current, accurate, and complete data relevant to the buy alternative.

Outsourcing

Outsourcing transfers some of what are traditional internal activities and resources of a firm to outside vendors, making it slightly different from the traditional make-or-buy decision. Outsourcing, discussed in Chapter 2, is part of the continuing trend toward using the efficiency that comes with specialization. The vendor performing the outsourced service is an expert in that particular specialty. This leaves the outsourcing firm to focus on its key success factors and its core competencies.

Make-or-buy decision

A choice between producing a component or service in-house or purchasing it from an outside source.

Outsourcing

Transferring a firm's activities that have traditionally been internal to external suppliers.

Six Sourcing Strategies

Having decided *what* to outsource, managers have six strategies to consider.

LO 11.2 *Identify* six sourcing strategies

Many Suppliers

With the many-suppliers strategy, a supplier responds to the demands and specifications of a "request for quotation," with the order usually going to the low bidder. This is a common strategy when products are commodities. This strategy plays one supplier against another and places the burden of meeting the buyer's demands on the supplier. Suppliers aggressively compete with one another. This approach holds the supplier responsible for maintaining the necessary technology, expertise, and forecasting abilities, as well as cost, quality, and delivery competencies. Long-term "partnering" relationships are not the goal.

Few Suppliers

A strategy of few suppliers implies that rather than looking for short-term attributes, such as low cost, a buyer is better off forming a long-term relationship with a few dedicated suppliers. Long-term suppliers are more likely to understand the broad objectives of the procuring firm and the end customer. Using few suppliers can create value by allowing suppliers to have economies of scale and a learning curve that yields both lower transaction costs and lower production costs. This strategy also encourages those suppliers to provide design innovations and technological expertise.

Ford chooses suppliers even before parts are designed. Motorola evaluates suppliers on rigorous criteria, but in many instances has eliminated traditional supplier bidding, placing added emphasis on quality and reliability. On occasion these relationships yield contracts that extend through the product's life cycle. The British retailer Marks & Spencer finds that cooperation with its suppliers yields new products that win customers for the supplier and themselves. The move toward tight integration of the suppliers and purchasers is occurring in both manufacturing and services.

As with all other strategies, a downside exists. With few suppliers, the cost of changing partners is huge, so both buyer and supplier run the risk of becoming captives of the other. Poor supplier performance is only one risk the purchaser faces. The purchaser must also be concerned about trade secrets and suppliers that make other alliances or venture out on their own. This happened when the U.S. Schwinn Bicycle Co., needing additional capacity, taught Taiwan's Giant Manufacturing Company to make and sell bicycles. Giant Manufacturing is now the largest bicycle manufacturer in the world, and Schwinn was acquired out of bankruptcy by Pacific Cycle LLC.

VIDEO 11.2
Supply Chain Management at Regal Marine

and stable quality production to the manufacturer. Members of the *keiretsu* can also have second- and even third-tier suppliers as part of the coalition.

Virtual Companies

Virtual companies rely on a variety of good, stable supplier relationships to provide services on demand. Suppliers may provide a variety of services that include doing the payroll, hiring personnel, designing products, providing consulting services, manufacturing components, conducting tests, or distributing products. The relationships may be short- or long-term and may include true partners, collaborators, or simply able suppliers and subcontractors. Whatever the formal relationship, the result can be exceptionally lean performance. The advantages of virtual companies include specialized management expertise, low capital investment, flexibility, and speed. The result is efficiency.

The apparel business provides a *traditional* example of virtual organizations. The designers of clothes seldom manufacture their designs; rather, they license the manufacture. The manufacturer may then rent space, lease sewing machines, and contract for labor. The result is an organization that has low overhead, remains flexible, and can respond rapidly to the market.

A *contemporary* example is exemplified by Vizio, Inc., a California-based producer of flat-screen TVs that has fewer than 100 employees but huge sales. Vizio uses modules to assemble its own brand of TVs. Because the key components of TVs are now readily available and sold almost as commodities, innovative firms such as Vizio can specify the components, hire a contract manufacturer, and market the TVs with very little startup cost. In a virtual company, the supply chain is the company. Managing it is dynamic and demanding.

> **Virtual companies**
>
> Companies that rely on a variety of supplier relationships to provide services on demand. Also known as hollow corporations or network companies.

Supply Chain Risk

In this age of increasing specialization, low communication cost, and fast transportation, companies are making less and buying more. This means more reliance on supply chains and more risk. Managing integrated supply chains is a strategic challenge. Having fewer suppliers makes the supplier and customer more dependent on each other, increasing risk for both.

Supply chain risks arise in many ways. As this mishap illustrates, expected shipments can literally sink into the ocean.

As this photo of the port of Charleston suggests, with over 16 million containers entering the U.S. annually, tracking location, content, and condition of trucks and containers is a challenge. But new technology may improve both security and JIT shipments.

Security and JIT

There is probably no society more open than the U.S. This includes its borders and ports—but they are swamped. Millions of containers enter U.S. ports each year, along with thousands of planes, cars, and trucks each day. Even under the best of conditions, some 5% of the container movements are misrouted, stolen, damaged, or excessively delayed.

Since the September 11, 2001, terrorist attacks, supply chains have become more complex. However, technological innovations in the supply chain are improving both security and inventory management, making logistics more reliable. Technology is now capable of knowing truck and container location, content, and condition. New devices can even detect broken container seals. Motion detectors can also be installed inside containers. Other sensors record interior data including temperature, shock, radioactivity, and whether a container is moving. Tracking lost containers, identifying delays, or just reminding individuals in the supply chain that a shipment is on its way will help expedite shipments.

Managing the Integrated Supply Chain

As managers move toward integration of the supply chain, substantial efficiencies are possible. The cycle of materials—as they flow from suppliers, to production, to warehousing, to distribution, to the customer—takes place among separate and often very independent organizations. It can lead to actions that may not optimize the entire chain. On the other hand, the supply chain is full of opportunities to reduce waste and enhance value. We now look at some of the significant *issues* and *opportunities*.

VIDEO 11.3
Arnold Palmer Hospital's Supply Chain

Issues in Managing the Integrated Supply Chain

Three issues complicate development of an efficient, integrated supply chain: local optimization, incentives, and large lots.

LO 11.3 *Explain* issues and opportunities in the supply chain

Local Optimization Members of the chain are inclined to focus on maximizing local profit or minimizing immediate cost based on their limited knowledge. Slight upturns in demand are overcompensated for because no one wants to be caught short. Similarly, slight downturns are overcompensated for because no one wants to be caught holding excess inventory. So fluctuations are magnified. For instance, a pasta distributor does not want to run out of pasta for its retail customers; the natural response to an extra large order from the retailer

between firms often use electronic data interchange (EDI), which is a standardized data-transmittal format for computerized communications between organizations. EDI also provides for the use of advanced shipping notice (ASN), which notifies the purchaser that the vendor is ready to ship. Although some firms are still moving to EDI and ASN, the Internet's ease of use and lower cost is proving more popular.

Drop shipping

Shipping directly from the supplier to the end consumer rather than from the seller, saving both time and reshipping costs.

Drop Shipping and Special Packaging Drop shipping means the supplier will ship directly to the end consumer, rather than to the seller, saving both time and reshipping costs. Other cost-saving measures include the use of special packaging, labels, and optimal placement of labels and bar codes on containers. The final location down to the department and number of units in each shipping container can also be indicated. Substantial savings can be obtained through management techniques such as these. Some of these techniques can be of particular benefit to wholesalers and retailers by reducing shrinkage (lost, damaged, or stolen merchandise) and handling cost.

For instance, Walmart Marketplace (Walmart.com) provides customers access to hundreds of thousands of additional products through approved retailers. Although orders from these retailers are combined in a common payment to Walmart.com, all shipping and returns are handled by the affiliate retailers.

Building the Supply Base

LO 11.4 *Describe* the steps in supplier selection

For those goods and services a firm buys, suppliers, also known as *vendors,* must be selected and actively managed. Supplier selection considers numerous factors, such as strategic fit, supplier competence, delivery, and quality performance. Because a firm may have some competence in all areas and may have exceptional competence in only a few, selection can be challenging. Procurement policies also need to be established. Those might address issues such as percent of business done with any one supplier or with minority businesses. We now examine supplier selection as a four-stage process: (1) supplier evaluation, (2) supplier development, (3) negotiations, and (4) contracting.

Supplier Evaluation

The first stage of supplier selection, *supplier evaluation,* involves finding potential suppliers and determining the likelihood of their becoming *good* suppliers. If good suppliers are not selected, then all other supply chain efforts are wasted. As firms move toward long-term suppliers, the issues of financial strength, quality, management, research, technical ability, and potential for a close, long-term relationship play an increasingly important role. Evaluation criteria critical to the firm might include these categories as well as production process capability, location, and information systems. The supplement to this chapter provides an example of the commonly used *factor weighting* approach to supplier evaluation.

Supplier Certification International quality certifications such as ISO 9000 and ISO 14000 are designed to provide an external verification that a firm follows sound quality management and environmental management standards. Buying firms can use such certifications to pre-qualify potential suppliers. Despite the existence of the ISO standards, firms often create their own supplier certification programs. Buyers audit potential suppliers and award a certified status to those that meet the specified qualification. A certification process often involves three steps: (1) qualification, (2) education, and (3) the certification performance process. Once certified, the supplier may be awarded special treatment and priority, allowing the buying firm to reduce or eliminate incoming inspection of materials. Such an arrangement may facilitate JIT production for the buying firm. Most large companies use some sort of supplier certification program.

Supplier Development

The second stage of supplier selection is *supplier development*. Assuming that a firm wants to proceed with a particular supplier, how does it integrate this supplier into its system?

- Devote more resources to the supplier selection and negotiation process
- Reduce the duplication of tasks
- Promote standardization

However, local managers enjoy having their own purchasing control, and decentralized purchasing can offer certain inventory control, transportation cost, or lead-time benefits. Often firms use a hybrid approach—using centralized purchasing for some items and/or sites while allowing local purchasing for others.

E-Procurement

E-procurement

Purchasing facilitated through the Internet.

E-procurement speeds purchasing, reduces costs, and integrates the supply chain. It reduces the traditional barrage of paperwork and, at the same time, provides purchasing personnel with an extensive database of supplier, delivery, and quality data.

Online Catalogs and Exchanges   Purchase of standard items is often accomplished via online catalogs. Such catalogs support cost comparisons and incorporate voice and video clips, making the process efficient for both buyers and sellers.

Online exchanges are typically industry-specific Internet sites that bring buyers and sellers together. Marriott and Hyatt created one of the first, Avendra (**www.avendra.com**), which facilitates economic purchasing of the huge range of goods needed by the 5,000 hospitality industry customers now in the exchange. Online catalogs and exchanges can help move companies from a multitude of individual phone calls, faxes, and emails to a centralized system and drive billions of dollars of waste out of the supply chain.

Online Auctions   In addition to catalogs, some suppliers and buyers have established online auction sites. Operations managers find online auctions a fertile area for disposing of excess raw material and discontinued or excess inventory. Online auctions lower entry barriers, encourage sellers to join, and simultaneously increase the potential number of buyers. The key for intermediaries is to find and build a huge base of potential bidders, improve client buying procedures, and qualify new suppliers.

In a traditional auction, a seller offers a product or service and generates competition between bidders—bidding the price up. In contrast, buyers often utilize online *reverse auctions* (or *Dutch auctions*). In reverse auctions, a buyer initiates the process by submitting a description of the desired product or service. Potential suppliers then submit bids, which may include price and other delivery information. Thus, price competition occurs on the selling side of the transaction—bidding the price down. Note that, as with traditional supplier selection decisions, price is important but may not be the only factor in winning the bid.

Logistics Management

Logistics management

An approach that seeks efficiency of operations through the integration of all material acquisition, movement, and storage activities.

Procurement activities may be combined with various shipping, warehousing, and inventory activities to form a logistics system. The purpose of logistics management is to obtain efficiency of operations through the integration of all material acquisition, movement, and storage activities. When transportation and inventory costs are substantial on both the input and output sides of the production process, an emphasis on logistics may be appropriate. Many firms opt for outsourcing the logistics function, as logistics specialists can often bring expertise not available in-house. For instance, logistics companies often have tracking technology that reduces transportation losses and supports delivery schedules that adhere to precise delivery windows. The potential for competitive advantage is found via both reduced costs and improved customer service.

Shipping Systems

LO 11.5 *Explain* major issues in logistics management

Firms recognize that the transportation of goods to and from their facilities can represent as much as 25% of the cost of products. Because of this high cost, firms constantly evaluate their means of shipping. Six major means of shipping are trucking, railroads, airfreight, waterways, pipelines, and multimodal.

provides another example of how outsourcing logistics can reduce costs while shrinking inventory and delivery times.

Distribution Management

Management of the supply chain focuses on incoming materials, but just as important, *distribution management* focuses on the outbound flow of products. Designing distribution networks to meet customer expectations suggests three criteria: (1) *rapid response,* (2) *product choice,* and (3) *service.*

Office Depot, for example, addresses these customer concerns by having several stores in a town for convenience and quick response time. But it also offers an online shopping presence to accommodate customers requiring a much larger selection of products (**www.officedepot.com**). It may even offer delivery directly to large customers. These varying customer expectations suggest both different distribution channels and multiple outlets.

So how many stores should Office Depot open in a town? As Figure 11.3(a) indicates, an increase in the number of facilities generally implies a quicker response and increased customer satisfaction. On the cost side, three logistics-related costs [see Figure 11.3(b) are shown: *inventory costs*, *transportation costs*, and *facility costs.* Taken together, *total logistics costs* tend to follow the top curve, first declining, and then rising. For this particular example, it appears that total logistics costs are minimized with three facilities. However, when revenue is considered [see Figure 11.3(c)], we note that profit is maximized with four facilities.

Whether creating a network of warehouses or retail outlets, finding the optimal number of facilities represents a critical and often dynamic decision. For instance, barely a year after adding 3 million square feet of warehouse capacity, market dynamics caused Amazon.com to close three of its U.S. distribution centers.

Just as firms need an effective *supplier management* program, an effective *distribution management* program may make the difference between supply chain success and failure. For example, in addition to facilities, packaging and logistics are necessary for the network to perform well. Packaging and logistics are also important distribution decisions because the manufacturer is usually held responsible for breakages and serviceability. Further, selection and development of dealers or retailers are necessary to ensure ethical and enthusiastic representation of the firm's products. Top-notch supply chain performance requires good *downstream* (distributors and retailers) management, just as it does good *upstream* (suppliers) management.
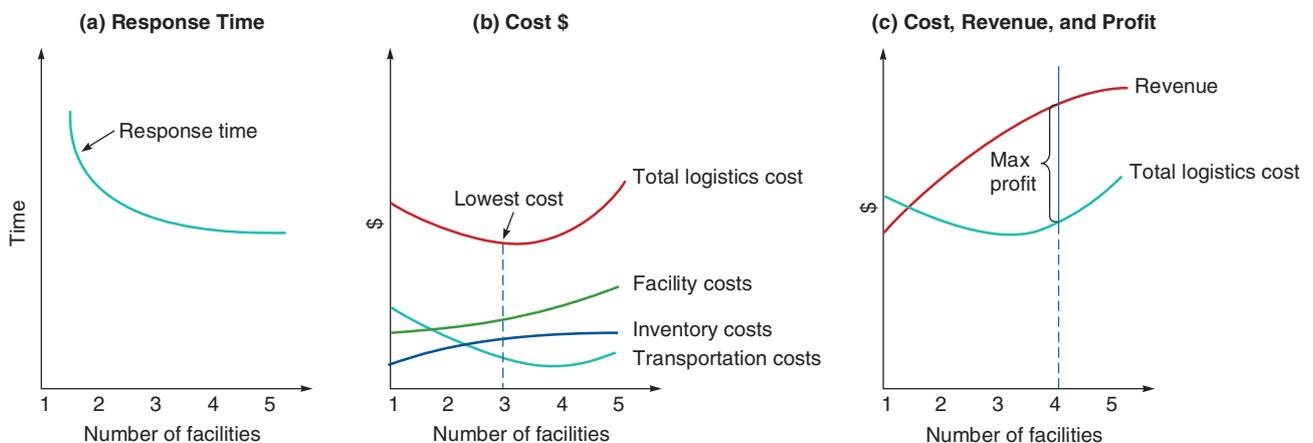

Figure **11.3**

Number of Facilities in a Distribution Network

The focus should be on profit maximization (c) rather than cost minimization (b).

Ethics and Sustainable Supply Chain Management

Let's look at two issues that OM managers must address every day when dealing with supply chains: ethics and sustainability.

Supply Chain Management Ethics

We consider three aspects of ethics: personal ethics, ethics within the supply chain, and ethical behavior regarding the environment. As the supply chain becomes increasingly international, each of these becomes even more significant.

Personal Ethics   Ethical decisions are critical to the long-term success of any organization. However, the supply chain is particularly susceptible to ethical lapses. With sales personnel anxious to sell and purchasing agents spending huge sums, temptations abound. Salespeople become friends with customers, do favors for them, take them to lunch, or present small (or large) gifts. Determining when tokens of friendship become bribes can be challenging. Many companies have strict rules and codes of conduct that limit what is acceptable.

Recognizing these issues, the Institute for Supply Management has developed the following principles and standards to be used as guidelines for ethical behavior:

◆ *Promote and uphold* responsibilities to one's employer; positive supplier and customer relationships; sustainability and social responsibility; protection of confidential and proprietary information; applicable laws, regulations, and trade agreements; and development of professional competence.

◆ *Avoid* perceived impropriety; conflicts of interest; behaviors that negatively influence supply chain decisions; and improper reciprocal agreements.

Ethics Within the Supply Chain   In this age of hyper-specialization, much of any organization's resources are purchased, putting great stress on ethics in the supply chain. Managers may be tempted to ignore ethical lapses by suppliers or offload pollution to suppliers. But firms must establish standards for their suppliers, just as they have established standards for themselves. Society expects ethical performance throughout the supply chain. For instance, Gap, Inc., reported that of its 3,000-plus factories worldwide, about 90% failed their initial evaluation. Gap found that 10% to 25% of its Chinese factories engaged in psychological or verbal abuse, and more than 50% of the factories in sub-Saharan Africa operated without proper safety devices. The challenge of enforcing ethical standards is significant, but responsible firms such as Gap are finding ways to deal with this difficult issue.

Ethical Behavior Regarding the Environment   While ethics on both a personal basis and in the supply chain are important, so is ethical behavior in regard to the environment. Good ethics extends to doing business in a way that supports conservation and renewal of resources. This requires evaluation of the entire environmental impact, from raw material, to manufacture, through use and final disposal. For instance, Darden Restaurants and Walmart both require their shrimp and fish suppliers in Southeast Asia to abide by the standards of the Global Aquaculture Alliance. These standards must be met if suppliers want to maintain the business relationship. Operations managers also ensure that sustainability is reflected in the performance of second- and third-tier suppliers. Enforcement can be done by in-house inspectors, third-party auditors, governmental agencies, or nongovernmental watchdog organizations. All four approaches are used.

Establishing Sustainability in Supply Chains

Reverse logistics
The process of sending returned products back up the supply chain for value recovery or disposal.

The incoming supply chain garners most of the attention, but it is only part of the challenge of sustainability. The "return" supply chain is also significant. Reverse logistics involves the processes for sending returned products back up the supply chain for resale, repair, reuse, remanufacture, recycling, or disposal. The operations manager's goal should be to limit burning or

TABLE 11.4	Management Challenges of Reverse Logistics	
ISSUE	**FORWARD LOGISTICS**	**REVERSE LOGISTICS**
Forecasting	Relatively straightforward	More uncertain
Product quality	Uniform	Not uniform
Product packaging	Uniform	Often damaged
Pricing	Relatively uniform	Dependent on many factors
Speed	Often very important	Often not a priority
Distribution costs	Easily visible	Less directly visible
Inventory management	Consistent	Not consistent

Adapted from the Reverse Logistics Executive Council (**www.rlec.org**).

burying of returned products and instead strive for reuse. Reverse logistics initiates a new set of challenges, as shown in Table 11.4.

Although sometimes used as a synonym for reverse logistics, a **closed-loop supply chain** refers more to the proactive design of a supply chain that tries to optimize all forward and reverse flows. A closed-loop supply chain prepares for returns prior to product introduction. For instance, IBM has recognized that components often have much longer life cycles than the original products that they go into. So the company has established a systematic method for dismantling returns and used equipment to extract components that still have value, such as boards, cards, and hard-disk assemblies. IBM has realized millions of dollars of savings in procurement costs by exploiting its "dismantling channel" of used parts.

Closed-loop supply chain
A supply chain designed to optimize both forward and reverse flows.

Measuring Supply Chain Performance

♦ **STUDENT TIP**
If you can't measure it, you can't control it.

Like all other managers, supply chain managers require standards (or *metrics*, as they are often called) to evaluate performance. For example, the large grocery chain HEB tracks metrics such as total freight cost per $1 million of sales, errors and returns in distribution, and lead-time compliance. Lancers, a beverage dispenser manufacturer, tracks metrics such as on-time delivery percentage, defects per million, and lead time. We now introduce several financial-based inventory metrics.

Assets Committed to Inventory

Supply chain managers make scheduling and quantity decisions that determine the assets committed to inventory. Three specific measures can be helpful here. The first is the amount of money invested in inventory, usually expressed as a percentage of assets, as shown in Equation (11-1) and Example 2:

LO 11.6 *Compute* the percentage of assets committed to inventory and inventory turnover

Percentage invested in inventory = (Average inventory investment/Total assets) × 100 (11-1)

Example 2

TRACKING HOME DEPOT'S INVENTORY INVESTMENT

Home Depot's management wishes to track its investment in inventory as one of its performance measures. Recently, Home Depot had $11.4 billion invested in inventory and total assets of $44.4 billion.

APPROACH ▶ Determine the investment in inventory and total assets and then use Equation (11-1).

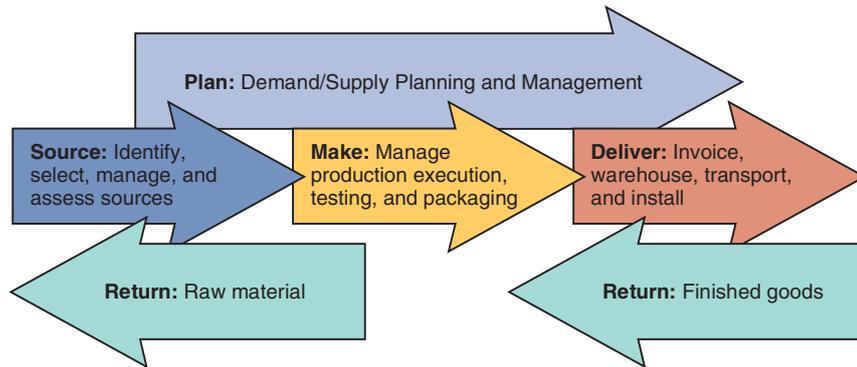**SOLUTION ▶** Percent invested in inventory = $(11.4/44.4) \times 100 = 25.7\%$

INSIGHT ▶ Over one-fourth of Home Depot assets are committed to inventory.

LEARNING EXERCISE ▶ If Home Depot can drive its investment down to 20% of assets, how much money will it free up for other uses? [Answer: $11.4 - (44.4 \times 0.2) = \$2.52$ billion.]

RELATED PROBLEMS ▶ 11.5b, 11.6b

Figure **11.4**

The Supply Chain Operations Reference (SCOR) Model

Plan: Demand/Supply Planning and Management

Source: Identify, select, manage, and assess sources

Make: Manage production execution, testing, and packaging

Deliver: Invoice, warehouse, transport, and install

Return: Raw material

Return: Finished goods

(distribution activities), and Return (closed-loop supply chain activities). The system is maintained by the APICS Supply Chain Council (**www.apics.org/sites/apics-supply-chain-council**). Firms use SCOR to identify, measure, reorganize, and improve supply chain processes.

The SCOR model defines over 200 process elements, 550 measurable metrics, and 500 best practices. The best practices describe the techniques used by benchmark firms that have scored very well on the metrics. SCOR combines these metrics with "Performance Attributes" (see Table 11.8) to facilitate comparisons of companies that compete by using different strategies (for example, low cost vs. responsiveness).

TABLE 11.8   SCOR Model Metrics to Help Firms Benchmark Performance Against the Industry

PERFORMANCE ATTRIBUTE	SAMPLE METRIC	CALCULATION
Supply chain reliability	Perfect order fulfillment	(Total perfect orders)/(Total number of orders)
Supply chain responsiveness	Average order fulfillment cycle time	(Sum of actual cycle times for all orders delivered)/(Total number of orders delivered)
Supply chain agility	Upside supply chain flexibility	Time required to achieve an unplanned 20% increase in delivered quantities
Supply chain costs	Supply chain management cost	Cost to plan + Cost to source + Cost to deliver + Cost to return
Supply chain asset management	Cash-to-cash cycle time	Inventory days of supply + Days of receivables outstanding − Days of payables outstanding

Benchmarking can be very useful, but it is not always adequate for excellence in the supply chain. Audits based on continuing communication, understanding, trust, performance, and corporate strategy are necessary. The relationships should manifest themselves in the mutual belief that "we are in this together" and go well beyond written agreements.

Summary

Competition is no longer between companies but between supply chains. The key to success is to collaborate with members on both the supply side and the distribution side of the supply chain to make decisions that will benefit the whole channel. For many firms, the supply chain determines a substantial portion of product cost and quality, as well as opportunities for responsiveness and differentiation. The challenge of building a great supply chain is significant, but with good sourcing tactics, a thoughtful logistics plan, and active management of the distribution network, each link in the chain can be firmly forged. A number of metrics are available to help managers evaluate their supply chain performance and benchmark against the industry. Skillful supply chain management provides a great strategic opportunity for competitive advantage.

Key Terms

Ethical Dilemma

As a buyer for a discount retail chain, you find yourself caught in a maelstrom. Just last month, your chain began selling an economy-priced line of clothing endorsed by a famous movie star. To be price competitive, you have followed the rest of the industry and sourced the clothing from a low-wage region of Asia. Initial sales have been brisk; however, the movie star has recently called you screaming and crying because an investigative news outlet has reported that the clothes with her name on them are being made by children.

Outraged, you fly to the outsourcing manufacturing facility only to find that conditions are not quite as clear-cut as the news had reported. You feel uncomfortable riding through the streets. Poverty is everywhere. Children are chasing foreigners and begging for money. When you enter the plant, you observe a very clean facility. The completely female workforce appears to be very industrious, but many of them do appear to be young. You confront the plant manager and explain your firm's strict international sourcing policies. You demand to know why these girls aren't in school. The manager provides the following response: "The truth is that some of these workers may be underage. We check IDs, but the use of falsified records is commonplace in this country. Plus, you don't understand the alternatives. If you shut this plant down, you will literally take food off the table for these families. There are no other opportunities in this town at this time, and there's no comprehensive welfare system in our country. As for the young women, school is not an option. In this town, only boys receive an education past the sixth grade. If you shut us down, these girls will be out on the street, begging, stealing, or prostituting themselves. Your business offers them a better existence. Please don't take that away!"

What do you say to your company, the movie star, the media, and the protestors picketing your stores? Is the best option to shut down and try someplace else?

Discussion Questions

1. Define *supply chain management*.
2. What are the objectives of supply chain management?
3. What is the objective of logistics management?
4. How do we distinguish between the types of risk in the supply chain?
5. What is vertical integration? Give examples of backward and forward integration.
6. What are three basic approaches to negotiations?
7. How does a traditional adversarial relationship with suppliers change when a firm makes a decision to move to a few suppliers?
8. What is the difference between postponement and channel assembly?
9. What is CPFR?
10. What is the value of online auctions in e-commerce?
11. Explain how FedEx uses the Internet to meet requirements for quick and accurate delivery.
12. How does Walmart use drop shipping?
13. What are blanket orders? How do they differ from invoiceless purchasing?
14. What can purchasing do to implement just-in-time deliveries?
15. What is e-procurement?
16. How does Darden Restaurants, described in the *Global Company Profile*, find competitive advantage in its supply chain?
17. What is SCOR, and what purpose does it serve?

Solved Problems   Virtual Office Hours help is available in MyOMLab.

SOLVED PROBLEM 11.1

Jack's Pottery Outlet has total end-of-year assets of $5 million. The first-of-the-year inventory was $375,000, with a year-end inventory of $325,000. The annual cost of goods sold was $7 million. The owner, Eric Jack, wants to evaluate his supply chain performance by measuring his percent of assets in inventory, his inventory turnover, and his weeks of supply. We use Equations (11-1), (11-2), and (11-3) to provide these measures.

SOLUTION

First, determine *average inventory*:

$$(\$375,000 + \$325,000)/2 = \$350,000$$

Then, use Equation (11-1) to determine percent invested in inventory:

$$\text{Percent invested in inventory} = (\text{Average inventory investment}/\text{Total assets}) \times 100$$
$$= (350{,}000/5{,}000{,}000) \times 100$$
$$= 7\%$$

Third, determine inventory turnover, using Equation (11-2):

$$\text{Inventory turnover} = \text{Cost of goods sold}/\text{Average inventory investment}$$
$$= 7{,}000{,}000/350{,}000$$
$$= 20$$

Finally, to determine weeks of inventory, use Equation (11-3), adjusted to weeks:

$$\text{Weeks of inventory} = \text{Average inventory investment}/\text{Weekly cost of goods sold}$$
$$= 350{,}000/(7{,}000{,}000/52)$$
$$= 350{,}000/134{,}615$$
$$= 2.6$$

We conclude that Jack's Pottery Outlet has 7% of its assets invested in inventory, that the inventory turnover is 20, and that weeks of supply is 2.6.

Problems

Problems 11.1–11.3 relate to The Supply Chain's Strategic Importance

•• **11.1** Choose a local establishment that is a member of a relatively large chain. From interviews with workers and information from the Internet, identify the elements of the supply chain. Determine whether the supply chain supports a low-cost, rapid response, or differentiation strategy (refer to Chapter 2). Are the supply chain characteristics significantly different from one product to another?

••• **11.2** Hau Lee Furniture, Inc., described in Example 1 of this chapter, finds its current profit of $10,000 inadequate. The bank is insisting on an improved profit picture prior to approval of a loan for some new equipment. Hau would like to improve the profit line to $25,000 so he can obtain the bank's approval for the loan.
a) What percentage improvement is needed in the *supply chain strategy* for profit to improve to $25,000? What is the cost of material with a $25,000 profit?
b) What percentage improvement is needed in the *sales strategy* for profit to improve to $25,000? What must sales be for profit to improve to $25,000?

•••• **11.3** Kamal Fatehl, production manager of Kennesaw Manufacturing, finds his profit at $15,000 (as shown in the statement below)—inadequate for expanding his business. The bank is insisting on an improved profit picture prior to approval of a loan for some new equipment. Kamal would like to improve the profit line to $25,000 so he can obtain the bank's approval for the loan.

		% OF SALES
Sales	$250,000	100%
Cost of supply chain purchases	175,000	70%
Other production costs	30,000	12%
Fixed costs	30,000	12%
Profit	15,000	6%

a) What percentage improvement is needed in a *supply chain strategy* for profit to improve to $25,000? What is the cost of material with a $25,000 profit?
b) What percentage improvement is needed in a *sales strategy* for profit to improve to $25,000? What must sales be for profit to improve to $25,000? (*Hint:* See Example 1.)

Problem 11.4 relates to Six Sourcing Strategies

•• **11.4** Using sources from the Internet, identify some of the problems faced by a company of your choosing as it moves toward, or operates as, a virtual organization. Does its operating as a virtual organization simply exacerbate old problems, or does it create new ones?

Problems 11.5–11.8 relate to Measuring Supply Chain Performance

•• **11.5** Baker Mfg. Inc. (see Table 11.9) wishes to compare its inventory turnover to those of industry leaders, who have turnover of about 13 times per year and 8% of their assets invested in inventory.
a) What is Baker's inventory turnover?
b) What is Baker's percent of assets committed to inventory?
c) How does Baker's performance compare to the industry leaders?

TABLE 11.9	For Problems 11.5 and 11.6
ARROW DISTRIBUTING CORP.	
Net revenue	$16,500
Cost of sales	$13,500
Inventory	$ 1,000
Total assets	$ 8,600
BAKER MFG. INC.	
Net revenue	$27,500
Cost of sales	$21,500
Inventory	$ 1,250
Total assets	$16,600

•• **11.6** Arrow Distributing Corp. (see Table 11.9) likes to track inventory by using weeks of supply as well as by inventory turnover.
a) What is its weeks of supply?
b) What percent of Arrow's assets are committed to inventory?
c) What is Arrow's inventory turnover?
d) Is Arrow's supply chain performance, as measured by these inventory metrics, better than that of Baker in Problem 11.5?

• **11.7** The grocery industry has an annual inventory turnover of about 14 times. Organic Grocers, Inc. had a cost of goods sold last year of $10.5 million; its average inventory was $1.0 million. What was Organic Grocers' inventory turnover, and how does that performance compare with that of the industry?

•• **11.8** Mattress Wholesalers, Inc., is constantly trying to reduce inventory in its supply chain. Last year, cost of goods sold was $7.5 million and inventory was $1.5 million. This year, cost of goods sold is $8.6 million and inventory investment is $1.6 million.
a) What were the weeks of supply last year?
b) What are the weeks of supply this year?
c) Is Mattress Wholesalers making progress in its inventory-reduction effort?

Tyler Olson/Fotolia

CASE STUDIES

Darden's Global Supply Chains

Video Case 📷

Darden Restaurants (subject of the *Global Company Profile* at the beginning of this chapter), owner of popular brands such as Olive Garden and LongHorn Steakhouse, requires unique supply chains to serve more than 300 million meals annually. Darden's strategy is operations excellence, and Senior VP Jim Lawrence's task is to ensure competitive advantage via Darden's supply chains. For a firm with purchases exceeding $1.8 billion, managing the supply chains is a complex and challenging task.

Darden, like other casual dining restaurants, has unique supply chains that reflect its menu options. Darden's supply chains are rather shallow, often having just one tier of suppliers. But it has four distinct supply chains.

First, "smallware" is a restaurant industry term for items such as linens, dishes, tableware and kitchenware, and silverware. These are purchased, with Darden taking title as they are received at the Darden Direct Distribution (DDD) warehouse in Orlando, Florida. From this single warehouse, smallware items are shipped via common carrier (trucking companies) to Olive Garden, Bahama Breeze, and Seasons 52 restaurants.

Second, frozen, dry, and canned food products are handled economically by Darden's 11 distribution centers in North America, which are managed by major U.S. food distributors, such as MBM, Maines, and Sygma. This is Darden's second supply line.

Third, the fresh food supply chain (not frozen and not canned), where product life is measured in days, includes dairy products, produce, and meat. This supply chain is B2B, where restaurant managers directly place orders with a preselected group of independent suppliers.

Fourth, Darden's worldwide seafood supply chain is the final link. Here Darden has developed independent suppliers of salmon, shrimp, tilapia, scallops, and other fresh fish that are source inspected by Darden's overseas representatives to ensure quality. These fresh products are flown to the U.S. and shipped to 16 distributors, with 22 locations, for quick delivery to the restaurants. With suppliers in 35 countries, Darden must be on the cutting edge when it comes to collaboration, partnering, communication, and food safety. It does this with heavy travel schedules for purchasing and quality control personnel, native-speaking employees onsite, and aggressive communication. Communication is a critical element; Darden tries to develop as much forecasting transparency as possible. "Point of sale (POS) terminals," says Lawrence, "feed actual sales every night to suppliers."

Discussion Questions*

1. What are the advantages of each of Darden's four supply chains?
2. What are the complications of having four supply chains?
3. Where would you expect ownership/title to change in each of Darden's four supply chains?
4. How do Darden's four supply chains compare with those of other firms, such as Dell or an automobile manufacturer? Why do the differences exist, and how are they addressed?

*You may wish to view the video that accompanies this case before answering the questions.

Supply Chain Management at Regal Marine

Video Case 📷

Like most other manufacturers, Regal Marine finds that it must spend a huge portion of its revenue on purchases. Regal has also found that the better its suppliers understand its end users, the better are both the supplier's product and Regal's final product. As one of the 10 largest U.S. power boat manufacturers, Regal is trying to differentiate its products from the vast number of boats supplied by 300 other companies. Thus, the firm works closely with suppliers to ensure innovation, quality, and timely delivery.

Regal has done a number of things to drive down costs while driving up quality, responsiveness, and innovation. First, working on partnering relationships with suppliers ranging from providers of windshields to providers of instrument panel controls, Regal has brought timely innovation at reasonable cost to its product. Key vendors are so tightly linked with the company that they meet with designers to discuss material changes to be incorporated into new product designs.

Second, the company has joined about 15 other boat manufacturers in a purchasing group, known as American Boat Builders Association, to work with suppliers on reducing the costs of large purchases. Third, Regal is working with a number of local vendors to supply hardware and fasteners directly to the assembly line on a just-in-time basis. In some of these cases, Regal has worked out an arrangement with the vendor so that title does not transfer until parts are used by Regal. In other cases, title transfers when items are delivered to the property. This practice drives down total inventory and the costs associated with large-lot delivery.

Finally, Regal works with a personnel agency to outsource part of the recruiting and screening process for employees. In all these cases, Regal is demonstrating innovative approaches to supply chain management that help the firm and, ultimately, the end user. The *Global Company Profile* featuring Regal Marine (which opens Chapter 5) provides further background on Regal's operations.

Discussion Questions*

1. What other techniques might Regal use to improve supply chain management?
2. What kind of response might members of the supply chain expect from Regal because of their "partnering" in the supply chain?
3. Why is supply chain management important to Regal?

*You may wish to view the video that accompanies this case before answering the questions.

Arnold Palmer Hospital's Supply Chain

Video Case

Arnold Palmer Hospital, one of the nation's top hospitals dedicated to serving women and children, is a large business with over 2,000 employees working in a 431-bed facility totaling 676,000 square feet in Orlando, Florida. Like many other hospitals, and other companies, Arnold Palmer Hospital had been a long-time member of a large buying group, one servicing 900 members. But the group did have a few limitations. For example, it might change suppliers for a particular product every year (based on a new lower-cost bidder) or stock only a product that was not familiar to the physicians at Arnold Palmer Hospital. The buying group was also not able to negotiate contracts with local manufacturers to secure the best pricing.

So in 2003, Arnold Palmer Hospital, together with seven other partner hospitals in central Florida, formed its own much smaller, but still powerful (with $200 million in annual purchases) Healthcare Purchasing Alliance (HPA) corporation. The new alliance saved the HPA members $7 million in its first year with two main changes. First, it was structured and staffed to ensure that the bulk of the savings associated with its contracting efforts went to its eight members. Second, it struck even better deals with vendors by guaranteeing a *committed* volume and signing not 1-year deals but 3- to 5-year contracts. "Even with a new internal cost of $400,000 to run HPA, the savings and ability to contract for what our member hospitals really want makes the deal a winner," says George DeLong, head of HPA.

Effective supply chain management in manufacturing often focuses on development of new product innovations and efficiency through buyer–vendor collaboration. However, the approach in a service industry has a slightly different emphasis. At Arnold Palmer Hospital, supply chain opportunities often manifest themselves through the Medical Economic Outcomes Committee. This committee (and its subcommittees) consists of users (including the medical and nursing staff) who evaluate purchase options with a goal of better medicine while achieving economic targets. For instance, the heart pacemaker negotiation by the cardiology subcommittee allowed for the standardization to two manufacturers, with annual savings of $2 million for just this one product.

Arnold Palmer Hospital is also able to develop custom products that require collaboration down to the third tier of the supply chain. This is the case with custom packs that are used in the operating room. The custom packs are delivered by a distributor, McKesson General Medical, but assembled by a pack company that uses materials the hospital wanted purchased from specific manufacturers. The HPA allows Arnold Palmer Hospital to be creative in this way. With major cost savings, standardization, blanket purchase orders, long-term contracts, and more control of product development, the benefits to the hospital are substantial.

Discussion Questions*

1. How does this supply chain differ from that in a manufacturing firm?
2. What are the constraints on making decisions based on economics alone at Arnold Palmer Hospital?
3. What role do doctors and nurses play in supply chain decisions in a hospital? How is this participation handled at Arnold Palmer Hospital?
4. Doctor Smith just returned from the Annual Physician's Orthopedic Conference, where she saw a new hip joint replacement demonstrated. She decides she wants to start using the replacement joint at Arnold Palmer Hospital. What process will Dr. Smith have to go through at the hospital to introduce this new product into the supply chain for future surgical use?

*You may wish to view the video that accompanies this case before answering these questions.

Endnote

1. Inventory quantities often fluctuate wildly, and various types of inventory exist (e.g., raw material; work-in-process; finished goods; and maintenance, repair, and operating supplies [MRO]). Therefore, care must be taken when using inventory values; they may reflect more than just supply chain performance.

Chapter 11 *Rapid* Review

Main Heading	Review Material	
THE SUPPLY CHAIN'S STRATEGIC IMPORTANCE (pp. 444–446)	Most firms spend a huge portion of their sales dollars on purchases. ■ **Supply chain management**—Management of activities related to procuring materials and services, transforming them into intermediate goods and final products, and delivering them through a distribution system. *The objective is to build a chain of suppliers that focuses on maximizing value to the ultimate customer.* Competition is no longer between companies; it is between supply chains.	Concept Questions: 1.1–1.4 Problems: 11.2–11.3 **VIDEO 11.1** Darden's Global Supply Chain
SOURCING ISSUES: MAKE-OR-BUY AND OUTSOURCING (pp. 446–447)	■ **Make-or-buy decision**—A choice between producing a component or service within the firm or purchasing it from an outside source. ■ **Outsourcing**—Transferring to external suppliers a firm's activities that have traditionally been internal.	Concept Questions: 2.1–2.4
SIX SOURCING STRATEGIES (pp. 447–449)	Six supply chain strategies for goods and services to be obtained from outside sources are: 1. Negotiating with many suppliers and playing one supplier against another 2. Developing long-term partnering relationships with a few suppliers 3. Vertical integration 4. Joint ventures 5. Developing *keiretsu* networks 6. Developing virtual companies that use suppliers on an as-needed basis. ■ **Vertical integration**—Developing the ability to produce goods or services previously purchased or actually buying a supplier or a distributor. ■ ***Keiretsu***—A Japanese term that describes suppliers who become part of a company coalition. ■ **Virtual companies**—Companies that rely on a variety of supplier relationships to provide services on demand. Also known as hollow corporations or network companies.	Concept Questions: 3.1–3.4 **VIDEO 11.2** Supply Chain Management at Regal Marine
SUPPLY CHAIN RISK (pp. 449–451)	The development of a supply chain plan requires a thorough assessment of the risks involved. ■ **Cross-sourcing**—Using one supplier for a component and a second supplier for another component, where each supplier acts as a backup for the other.	Concept Questions: 4.1–4.4
MANAGING THE INTEGRATED SUPPLY CHAIN (pp. 451–454)	Supply chain integration success begins with mutual agreement on goals, followed by mutual trust, and continues with compatible organizational cultures. Three issues complicate the development of an efficient, integrated supply chain: local optimization, incentives, and large lots. ■ **Bullwhip effect**—Increasing fluctuation in orders or cancellations that often occurs as orders move through the supply chain. ■ **Pull data**—Accurate sales data that initiate transactions to "pull" product through the supply chain. ■ **Single-stage control of replenishment**—Fixing responsibility for monitoring and managing inventory for the retailer. ■ **Vendor-managed inventory (VMI)**—A system in which a supplier maintains material for the buyer, often delivering directly to the buyer's using department. ■ **Collaborative planning, forecasting, and replenishment (CPFR)**—A system in which members of a supply chain share information in a joint effort to reduce supply chain costs. ■ **Blanket order**—A long-term purchase commitment to a supplier for items that are to be delivered against short-term releases to ship. The purchasing department should make special efforts to increase levels of standardization. ■ **Postponement**—Delaying any modifications or customization to a product as long as possible in the production process. Postponement strives to minimize internal variety while maximizing external variety. ■ **Drop shipping**—Shipping directly from the supplier to the end consumer rather than from the seller, saving both time and reshipping costs. Online catalogs move companies from a multitude of individual phone calls, faxes, and e-mails to a centralized online system and drive billions of dollars of waste out of the supply chain.	Concept Questions: 5.1–5.4 **VIDEO 11.3** Arnold Palmer Hospital's Supply Chain
BUILDING THE SUPPLY BASE (pp. 454–456)	Supplier selection is a four-stage process: (1) supplier evaluation, (2) supplier development, (3) negotiations, and (4) contracting. *Supplier evaluation* involves finding potential vendors and determining the likelihood of their becoming good suppliers. *Supplier development* may include everything from training, to engineering and production help, to procedures for information transfer.	Concept Questions: 6.1–6.4

Main Heading	Review Material	MyOMLab
	Negotiations involve approaches taken by supply chain personnel to set prices. Three classic types of negotiation strategies are (1) the cost-based price model, (2) the market-based price model, and (3) competitive bidding. *Contracting* involves a design to share risks, share benefits, and create incentives so as to optimize the whole supply chain. ■ **E-procurement**—Purchasing facilitated through the Internet.	
LOGISTICS MANAGEMENT (pp. 456–459)	■ **Logistics management**—An approach that seeks efficiency of operations through the integration of all material acquisition, movement, and storage activities. Six major means of distribution are trucking, railroads, airfreight, waterways, pipelines, and multimodal. The vast majority of manufactured goods move by truck. Third-party logistics involves the outsourcing of the logistics function. ■ **Channel assembly**—A system that postpones final assembly of a product so the distribution channel can assemble it.	Concept Questions: 7.1–7.4
DISTRIBUTION MANAGEMENT (p. 459)	Distribution management focused on the outbound flow of final products. Total logistics costs are the sum of facility costs, inventory costs, and transportation costs (Figure 11.3). The optimal number of distribution facilities focuses on maximizing profit.	Concept Questions: 8.1–8.4
ETHICS AND SUS-TAINABLE SUPPLY CHAIN MANAGEMENT (pp. 460–461)	Ethics includes personal ethics, ethics within the supply chain, and ethical behavior regarding the environment. The Institute for Supply Management has developed a set of Principles and Standards for ethical conduct. ■ **Reverse logistics**—The process of sending returned products back up the supply chain for value recovery or disposal. ■ **Closed-loop supply chain**—A supply chain designed to optimize all forward and reverse flows.	Concept Questions: 9.1–9.4
MEASURING SUPPLY CHAIN PERFORMANCE (pp. 461–464)	Typical supply chain benchmark metrics include lead time, time spent placing an order, percent of late deliveries, percent of rejected material, and number of shortages per year: Percent invested in inventory = (Average inventory investment/Total assets) × 100 (11-1) ■ **Inventory turnover**—Cost of goods sold divided by average inventory: Inventory turnover = Cost of goods sold ÷ Average inventory investment (11-2) Weeks of supply = Average inventory investment ÷ (Annual cost of goods sold/52 weeks) (11-3) ■ **Supply Chain Operations Reference (SCOR) model**—A set of processes, metrics, and best practices developed by the APICS Supply Chain Council. The five parts of the SCOR model are Plan, Source, Make, Deliver, and Return.	Concept Questions: 10.1–10.4 Problems: 11.5–11.8 Virtual Office Hours for Solved Problem: 11.1

Self Test

■ **Before taking the self-test,** refer to the learning objectives listed at the beginning of the chapter and the key terms listed at the end of the chapter.

LO 11.1 The objective of supply chain management is to _____.

LO 11.2 The term *vertical integration* means to:
   a) develop the ability to produce products that complement or supplement the original product.
   b) produce goods or services previously purchased.
   c) develop the ability to produce the specified good more efficiently.
   d) all of the above.

LO 11.3 The bullwhip effect can be aggravated by:
   a) local optimization.
   b) sales incentives.
   c) quantity discounts.
   d) promotions.
   e) all of the above.

LO 11.4 Supplier selection requires:
   a) supplier evaluation and effective third-party logistics.
   b) supplier development and logistics.

   c) negotiations, supplier evaluation, supplier development, and contracts.
   d) an integrated supply chain.
   e) inventory and supply chain management.

LO 11.5 A major issue in logistics is:
   a) cost of purchases.
   b) supplier evaluation.
   c) product customization.
   d) cost of shipping alternatives.
   e) excellent e-procurement.

LO 11.6 Inventory turnover =
   a) Cost of goods sold ÷ Weeks of supply
   b) Weeks of supply ÷ Annual cost of goods sold
   c) Annual cost of goods sold ÷ 52 weeks
   d) Average inventory investment ÷ Cost of goods sold
   e) Cost of goods sold ÷ Average inventory investment

Answers: LO 11.1. build a chain of suppliers that focuses on maximizing value to the ultimate customer; LO 11.2. b; LO 11.3. e; LO 11.4. c; LO 11.5. d; LO 11.6. e.

Supply Chain Management Analytics

Alaska Airlines

The 2011 Tōhoku earthquake and tsunami devastated eastern sections of Japan. The economic impact was felt around the globe, as manufacturers had been relying heavily—in some cases exclusively—on suppliers located in the affected zones. In the month immediately following the earthquake, the Japanese-built vehicle outputs for both Toyota and Honda were down 63%. Plants in other countries ceased or reduced operations due to part shortages. Manufacturers in several industries worldwide took 6 months or longer before they saw their supply chains working normally again. Although disasters such as this one occur relatively infrequently, supply chain managers should consider their probabilities and repercussions when determining the makeup of the supply base.

mTaira/Shutterstock

Techniques for Evaluating Supply Chains

Many supply chain metrics exist that can be used to evaluate performance within a company as well as for its supply chain partners. This supplement introduces five techniques that are aimed at ways to build and evaluate performance of the supply chain.

Evaluating Disaster Risk in the Supply Chain

Disasters that disrupt supply chains can take many forms, including tornadoes, fires, hurricanes, typhoons, tsunamis, earthquakes, and terrorism. When you are deciding whether to purchase collision insurance for your car, the amount of insurance must be weighed against the probability of a minor accident occurring and the potential financial worst-case scenario if an accident happens (e.g., "totaling" of the car). Similarly, firms often use multiple suppliers for important components to mitigate the risks of total supply disruption.

LO S11.1 *Use a decision tree to determine the best number of suppliers to manage disaster risk*

As shown in Example S1, a decision tree can be used to help operations managers make this important decision regarding the number of suppliers. We will use the following notation for a given supply cycle:

S = the probability of a "super-event" that would disrupt *all* suppliers simultaneously

U = the probability of a "unique-event" that would disrupt only one supplier

L = the financial loss incurred in a supply cycle if *all* suppliers were disrupted

C = the marginal cost of managing a supplier

An interesting implication of Equation (S11-1) is that as the probability of a super-event (S) increases, the advantage of utilizing multiple suppliers diminishes (all would be knocked out anyway). On the other hand, large values of the unique event (U) increase the likelihood of needing more suppliers. These two phenomena taken together suggest that when multiple suppliers are used, managers may consider using ones that are geographically dispersed to lessen the probability of all failing simultaneously.

Managing the Bullwhip Effect

Figure S11.2 provides an example of the *bullwhip effect*, which describes the tendency for larger order size fluctuations as orders are relayed to the supply chain from retailers. "Bullwhip" fluctuations create unstable production schedules, resulting in expensive capacity change adjustments such as overtime, subcontracting, extra inventory, backorders, hiring and laying off of workers, equipment additions, underutilization, longer lead times, or obsolescence of overproduced items.

Procter & Gamble found that although the use of Pampers diapers was steady and the retail-store orders had little fluctuation, as orders moved through the supply chain, fluctuations increased. By the time orders were initiated for raw material, the variability was substantial. Similar behavior has been observed and documented at many companies, including Campbell Soup, Hewlett-Packard, Barilla SpA, and Applied Materials.

The bullwhip effect can occur when orders decrease as well as when they increase. Table S11.1 identifies some of the major causes and remedies of the bullwhip effect. Often the human tendency to overreact to stimuli causes managers to make decisions that exacerbate the phenomenon. The overarching solution to the bullwhip effect is simply for supply-chain members to share information and work together, as in the *OM in Action* box "RFID Helps Control the Bullwhip."

Supplier coordination can help with demand shifts. During the recent worldwide recession, but prior to experiencing the economic recovery and increasing sales, Caterpillar started ordering more supplies. It also worked proactively with its suppliers to prepare them for a sharp increase in output. Caterpillar visited key suppliers individually. In some cases it helped suppliers obtain bank financing at favorable rates. As part of Caterpillar's risk assessment activities, suppliers had to submit written plans describing their ability to ramp production back up once the economy improved. Careful, coordinated planning can help alleviate shortages and delays that might otherwise occur as the bullwhip snaps back upward.

Figure **S11.2**

The Bullwhip Effect

The bullwhip effect causes members of the supply chain to overreact to changes in demand at the retail level. Minor demand changes at the consumer level may result in large ones at the supplier level.
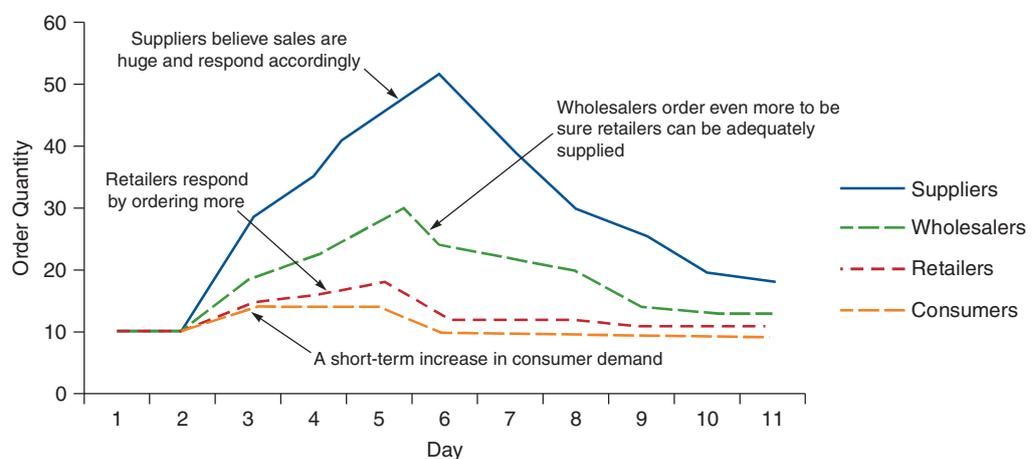
The U.S. *Cash for Clunkers* program produced an unintended bullwhip effect in the automobile industry. In an effort to stimulate the economy and improve fuel efficiency, the U.S. offered attractive rebates for trading old cars in exchange for new, more fuel-efficient vehicles. The $3 billion, 8-week program proved to be very popular with consumers. Fearing a shortage and assuming that they would not receive 100% of their orders, some dealers inflated orders for new cars to try to receive a larger pool of allocated vehicles. In one month, *Cash for Clunkers* increased demand by 50% for automakers, many of whom had already cut capacity significantly. Almost overnight, manufacturers and parts suppliers had to transform from a shift reduction mode to an overtime mode.

Paul Brennan/Shutterstock

Example S2

CALCULATING THE BULLWHIP EFFECT

Chieh Lee Metals, Inc. orders sheet metal and transforms it into 50 formed tabletops that are sold to furniture manufacturers. The table below shows the weekly variance of demand and orders for each major company in this supply chain for tables. Each firm has one supplier and one customer, so the order variance for one firm will equal the demand variance for its supplier. Analyze the relative contributions to the bullwhip effect in this supply chain.

FIRM	VARIANCE OF DEMAND	VARIANCE OF ORDERS	BULLWHIP MEASURE
Furniture Mart, Inc.	100	110	110/100 = 1.10
Furniture Distributors, Inc.	110	180	180/110 = 1.64
Furniture Makers of America	180	300	300/180 = 1.67
Chieh Lee Metals, Inc.	300	750	750/300 = 2.50
Metal Suppliers Ltd.	750	2000	2000/750 = 2.67

APPROACH ▶ Use Equation (S11-2) to calculate the bullwhip measure for each firm in the chain.

SOLUTION ▶ The last column of the table displays the bullwhip measure for each firm.

INSIGHT ▶ This supply chain exhibits a classic bullwhip effect. Despite what might be a very stable demand pattern at the retail level, order sizes to suppliers vary significantly. Chieh Lee should attempt to identifiy the causes for her own firm's order amplification, and she should attempt to work with her supply chain partners to try to reduce amplification at every level of the chain.

LEARNING EXERCISE ▶ Suppose that Chieh Lee is able to reduce her bullwhip measure from 2.50 to 1.20. If the measure for all other firms remained the same, what would be the new reduced variance of orders from Metal Suppliers? [Answer: 961.]

RELATED PROBLEMS ▶ S11.6, S11.7, S11.8, S11.9

Supplier Selection Analysis

Selecting suppliers from among a multitude of candidates can be a daunting task. Choosing suppliers simply based on the lowest bid has become a somewhat rare approach. Various, sometimes competing, factors often play a role in the decision. Buyers may consider such supplier characteristics as product quality, delivery speed, delivery reliability, customer service, and financial performance.

The *factor-weighting* technique, presented here, simultaneously considers multiple supplier criteria. Each factor must be assigned an importance *weight,* and then each potential supplier is *scored* on each factor. The weights typically sum to 100%. Factors are scored using the same scale (e.g., 1–10). Sometimes a key is provided for supplier raters that converts qualitative ratings into numerical scores (e.g., "Very good" = 8). Example S3 illustrates the weighted criteria in comparing two competing suppliers.

LO S11.3 *Describe* the factor-weighting approach to supplier evaluation

Example S3

FACTOR-WEIGHTING APPROACH TO SUPPLIER EVALUATION

Erick Davis, president of Creative Toys in Palo Alto, California, is interested in evaluating suppliers who will work with him to make nontoxic, environmentally friendly paints and dyes for his line of children's toys. This is a critical strategic element of his supply chain, and he desires a firm that will contribute to his product.

APPROACH ▶ Erick has narrowed his choices to two suppliers: Faber Paint and Smith Dye. He will use the factor-weighting approach to supplier evaluation to compare the two.

SOLUTION ▶ Erick develops the following list of selection criteria. He then assigns the weights shown to help him perform an objective review of potential suppliers. His staff assigns the scores and computes the total weighted score.

CRITERION	WEIGHT	FABER PAINT SCORE (1–5) (5 HIGHEST)	FABER PAINT WEIGHT × SCORE	SMITH DYE SCORE (1–5) (5 HIGHEST)	SMITH DYE WEIGHT × SCORE
Engineering/innovation skills	.20	5	1.0	5	1.0
Production process capability	.15	4	0.6	5	0.75
Distribution capability	.05	4	0.2	3	0.15
Quality performance	.10	2	0.2	3	0.3
Facilities/location	.05	2	0.1	3	0.15
Financial strength	.15	4	0.6	5	0.75
Information systems	.10	2	0.2	5	0.5
Integrity	.20	5	1.0	3	0.6
Total	1.00		3.9		4.2

Smith Dye received the higher score of 4.2 and, based on this analysis, would be the preferred vendor.

INSIGHT ▶ The use of a factor-weighting approach can help firms systematically identify the features that are important to them and evaluate potential suppliers in an objective manner. A certain degree of subjectivity remains in the process, however, with regard to the criteria chosen, the weights applied to those criteria, and the supplier scores that are applied to each criterion.

LEARNING EXERCISE ▶ If Erick believes that integrity should be twice as important while production process capability and financial strength should both only be 1/3 as important, how does the analysis change? [Answer: Faber Paint's score becomes 4.1, while Smith Dye's score becomes 3.8, so Faber Paint is now the preferred vendor.]

RELATED PROBLEMS ▶ S11.10, S11.11, S11.12 (S11.13 is available in MyOMLab)

Transportation Mode Analysis

The longer a product is in transit, the longer the firm has its money invested. But faster shipping is usually more expensive than slow shipping. A simple way to obtain some insight into this trade-off is to evaluate holding cost against shipping options. We do this in Example S4.

Example S4

LO S11.4 *Evaluate* cost-of-shipping alternatives

DETERMINING DAILY COST OF HOLDING

A shipment of new connectors for semiconductors needs to go from San Jose to Singapore for assembly. The value of the connectors is $1,750, and holding cost is 40% per year. One airfreight carrier can ship the connectors 1 day faster than its competitor, at an extra cost of $20.00. Which carrier should be selected?

APPROACH ▶ First we determine the daily holding cost and then compare the daily holding cost with the cost of faster shipment.

SOLUTION ▶ Daily cost of holding the product = (Annual holding cost × Product value)/365

$$= (.40 \times \$1{,}750)/365$$

$$= \$1.92$$

Because the cost of saving one day is $20.00, which is much more than the daily holding cost of $1.92, we decide on the less costly of the carriers and take the extra day to make the shipment. This saves $18.08 ($20.00 − $1.92).

INSIGHT ▶ The solution becomes radically different if the 1-day delay in getting the connectors to Singapore delays delivery (making a customer angry) or delays payment of a $150,000 final product. (Even 1 day's interest on $150,000 or an angry customer makes a savings of $18.08 insignificant.)

LEARNING EXERCISE ▶ If the holding cost is 100% per year, what is the decision? [Answer: Even with a holding cost of $4.79 per day, the less costly carrier is selected.]

RELATED PROBLEMS ▶ S11.14, S11.15, S11.16, S11.17

Example S4 looks only at holding cost versus shipping cost. For the operations or logistics manager there are many other considerations, including ensuring *on-time delivery*, coordinating shipments to maintain a schedule, getting a new product to market, and keeping a customer happy. Estimates of these other costs can be added to the estimate of the daily holding cost. Determining the impact and cost of these considerations makes the evaluation of shipping alternatives a challenging OM task.

Warehouse Storage

Storage represents a significant step for many items as they travel through their respective supply chains. The U.S. alone has more than 13,000 buildings dedicated to warehouse and storage. Some exceed the size of several connected football fields. In fact, more than 35% have over 100,000 square feet of floor space.

Care should be taken when determining which items to store in various locations in a warehouse. In large warehouses in particular, hundreds or thousands of trips are made each day along very long aisles. Proper placement of items can improve efficiency by shaving significant travel time for workers. In Example S5, we observe a simple way to determine storage locations in a warehouse.

Example S5

DETERMINING STORAGE LOCATIONS IN A WAREHOUSE

Erika Marsillac manages a warehouse for a local chain of specialty hardware stores. As seen in Figure S11.3, the single-aisle rectangular warehouse has a dock for pickup and delivery, along with 16 equal-sized storage blocks for inventory items.

Figure **S11.3**

Storage Locations in the Warehouse

The following table shows: (1) the category of each item stored in the warehouse, (2) the estimated number of times per month (trips) that workers need to either store or retrieve those items, and (3) the area (number of specialized blocks) required to store the items. Erika wishes to assign items to the storage blocks to minimize average distance traveled.

ITEM	MONTHLY TRIPS TO STORAGE	BLOCKS OF STORAGE SPACE NEEDED
Lumber	600	5
Paint	260	2
Tools	150	3
Small hardware	400	2
Chemical bags	90	3
Lightbulbs	220	1

LO S11.5 *Allocate* items to storage locations in a warehouse

APPROACH ▶ For each item, calculate the ratio of the number of trips to blocks of storage area needed. Rank the items according to this ratio, and place the *highest*-ranked items closest to the dock.

SOLUTION ▶ The following table calculates the ratio for each item and ranks the items from highest to lowest. Based on the ranking, items are assigned to the remaining blocks that are as close to the dock as possible. (Where applicable, given a choice between two equidistant blocks, items should be placed next to items of the same type rather than across the aisle from them.)

ITEM	TRIPS/BLOCKS	RANKING	ASSIGNED BLOCKS
Lumber	600/5 = 120	4	6, 7, 8, 9, 10
Paint	260/2 = 130	3	3, 5
Tools	150/3 = 50	5	11, 12, 13
Small hardware	400/2 = 200	2	2, 4
Chemical bags	90/3 = 30	6	14, 15, 16
Lightbulbs	220/1 = 220	1	1

INSIGHT ▶ This procedure allocates items with the highest "bang-for-the-buck" first. The "bang" (value) here is the number of trips. Because we want to minimize travel, we would like to place items with high-frequency visits near the front. The storage space represents the "buck" (cost). We want items that take up a lot of space moved toward the back because if they were placed near the front, we would have to travel past their multiple blocks every time we needed to store or retrieve an item from a different category. This bang versus buck trade-off is neatly accommodated by using the trips/blocks ratio (column 2 of the solution table). In this example, even though lumber has the highest number of trips, the lumber takes up so much storage space that it is placed further back, toward the middle of the warehouse.

LEARNING EXERCISE ▶ Order frequency for paint is expected to increase to 410 trips per month. How will that change the storage plan? [Answer: Paint and small hardware will switch storage locations.]

RELATED PROBLEMS ▶ S11.18, S11.19, S11.20

Summary

Myriad tools have been developed to help supply-chain managers make well-informed decisions. We have provided a small sampling in this supplement. A decision tree can help determine the best number of suppliers to protect against supply disruption from potential disasters. The bullwhip measure can identify each supply chain member's contribution to exacerbating ordering fluctuations.

The factor-weighting approach can be used to help select suppliers based on multiple criteria. Inventory holding costs can be computed for various shipping alternatives to better compare their overall cost impact. Finally, items can be ranked according to the ratio of (trips/ blocks of storage) to determine their best placement in a warehouse.

Discussion Questions

1. What is the difference between "unique-event" risk and "super-event" risk?
2. If the probability of a "super-event" increases, does the "unique-event" risk increase or decrease in importance? Why?
3. If the probability of a "super-event" decreases, what happens to the likelihood of needing multiple suppliers?
4. Describe some ramifications of the bullwhip effect.
5. Describe causes of the bullwhip effect and their associated remedies.
6. Describe how the bullwhip measure can be used to analyze supply chains.
7. Describe some potentially useful categories to include in a factor-weighting analysis for supplier selection.
8. Describe some potential pitfalls in relying solely on the results of a factor-weighting analysis for supplier selection.
9. Describe some disadvantages of using a slow shipping method.
10. Besides warehouse layout decisions, what are some other applications where ranking items according to "bang/buck" might make sense?

Solved Problems   Virtual Office Hours help is available in MyOMLab.

SOLVED PROBLEM S11.1

Jon Jackson Manufacturing is searching for suppliers for its new line of equipment. Jon has narrowed his choices to two sets of suppliers. Believing in diversification of risk, Jon would select two suppliers under each choice. However, he is still concerned about the risk of both suppliers failing at the same time. The "San Francisco option" uses both suppliers in San Francisco. Both are stable, reliable, and profitable firms, so Jon calculates the "unique-event" risk for either of them to be 0.5%. However, because San Francisco is in an earthquake zone, he estimates the probability of an event that would knock out both suppliers to be 2%. The "North American option" uses one supplier in Canada and another in Mexico. These are upstart firms; John calculates the "unique-event" risk for either of them to be 10%. But he estimates the "super-event" probability that would knock out both of these suppliers to be only 0.1%. Purchasing costs would be $500,000 per year using the San Francisco option and $510,000 per year using the North American option. A total disruption would create an annualized loss of $800,000. Which option seems best?

SOLUTION

Using Equation (S11-1), the probability of a total disruption (i.e., the probability of incurring the $800,000 loss) equals:

San Francisco option: $0.02 + (1 - 0.02)0.005^2 = 0.02 + 0.0000245 = 0.0200245$, or 2.00245%

North American option: $0.001 + (1 - 0.001)0.1^2 = 0.001 + 0.0099 = 0.01099$, or 1.099%

Total annual expected costs = Annual purchasing costs + Expected annualized disruption costs

San Francisco option: $500,000 + $800,000(0.0200245) = $500,000 + $16,020 = $516,020$

North American option: $510,000 + $800,000(0.01099) = $510,000 + $8,792 = $518,792$

In this case, the San Francisco option appears to be slightly cheaper.

SOLVED PROBLEM S11.2

Over the past 10 weeks, demand for gears at Michael's Metals has been 140, 230, 100, 175, 165, 220, 200, and 178. Michael has placed weekly orders of 140, 250, 90, 190, 140, 240, 190, and 168 units.

The sample variance of a data set can be found by using the VAR.S function in Excel or by plugging each value (x) of the data set into the formula: Variance $= \dfrac{\Sigma(x - \bar{x})^2}{(n - 1)}$, where $\bar{x}$ is the mean of the data set and n is the number of values in the set. Using Equation (S11-2), calculate the bullwhip measure for Michael's Metals over the 10-week period.

SOLUTION

Mean demand = $(140 + 230 + 100 + 175 + 165 + 220 + 200 + 178)/8 = 1,408/8 = 176$

Variance of demand

$$= \frac{(140 - 176)^2 + (230 - 176)^2 + (100 - 176)^2 + (175 - 176)^2 + (165 - 176)^2 + (220 - 176)^2 + (200 - 176)^2 + (178 - 176)^2}{(8 - 1)}$$

$$= \frac{36^2 + 54^2 + 76^2 + 1^2 + 11^2 + 44^2 + 24^2 + 2^2}{7} = \frac{1,296 + 2,916 + 5,776 + 1 + 121 + 1,936 + 576 + 4}{7}$$

$$= \frac{12,626}{7} = 1,804$$

Mean orders = $(140 + 250 + 90 + 190 + 140 + 240 + 190 + 168)/8 = 1,408/8 = 176$

Problems

• **S11.1**   How would you go about attempting to come up with the probability of a "super-event" or the probability of a "unique-event?" What factors would you consider?

•• **S11.2**   Phillip Witt, president of Witt Input Devices, wishes to create a portfolio of local suppliers for his new line of key-boards. As the suppliers all reside in a location prone to hurri-canes, tornadoes, flooding, and earthquakes, Phillip believes that the probability in any year of a "super-event" that might shut down all suppliers at the same time for at least 2 weeks is 3%. Such a total shutdown would cost the company approximately $400,000. He estimates the "unique-event" risk for any of the suppliers to be 5%. Assuming that the marginal cost of managing an additional supplier is $15,000 per year, how many suppliers should Witt Input Devices use? Assume that up to three nearly identical local suppliers are available.

•• **S11.3**   Still concerned about the risk in Problem S11.2, sup-pose that Phillip is willing to use one local supplier and up to two more located in other territories within the country. This would reduce the probability of a "super-event" to 0.5%, but due to increased distance the annual costs for managing each of the dis-tant suppliers would be $25,000 (still $15,000 for the local sup-plier). Assuming that the local supplier would be the first one chosen, how many suppliers should Witt Input Devices use now?

•• **S11.4**   Johnson Chemicals is considering two options for its supplier portfolio. Option 1 uses two local suppliers. Each has a "unique-event" risk of 5%, and the probability of a "super-event" that would disable both at the same time is estimated to be 1.5%. Option 2 uses two suppliers located in different countries. Each has a "unique-event" risk of 13%, and the probability of a "super-event" that would disable both at the same time is esti-mated to be 0.2%.
a) What is the probability that both suppliers will be disrupted using option 1?
b) What is the probability that both suppliers will be disrupted using option 2?
c) Which option would provide the lowest risk of a total shutdown?

•• **S11.5**   Bloom's Jeans is searching for new suppliers, and Debbie Bloom, the owner, has narrowed her choices to two sets. Debbie is very concerned about supply disruptions, so she has chosen to use three suppliers no matter what. For option 1, the suppliers are well established and located in the same country. Debbie calculates the "unique-event" risk for each of them to be 4%. She estimates the probability of a nationwide event that would knock out all three suppliers to be 2.5%. For option 2, the suppliers are newer but located in three different countries. Debbie calculates the "unique-event" risk for each of them to be 20%. She estimates the "super-event" probability that would knock out all three of these suppliers to be 0.4%. Purchasing and transportation costs would be $1,000,000 per year using option 1 and $1,010,000 per year using option 2. A total disruption would create an annualized loss of $500,000.
a) What is the probability that all three suppliers will be dis-rupted using option 1?
b) What is the probability that all three suppliers will be dis-rupted using option 2?

c) What is the total annual purchasing and transportation cost plus expected annualized disruption cost for option 1?
d) What is the total annual purchasing and transportation cost plus expected annualized disruption cost for option 2?
e) Which option seems best?

•• **S11.6**   Consider the supply chain illustrated below:

Manufacturer → Distributor → Wholesaler → Retailer
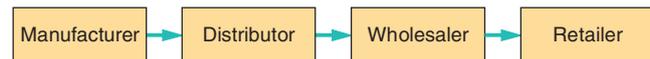
Last year, the retailer's weekly variance of demand was 200 units. The variance of orders was 500, 600, 750, and 1,350 units for the retailer, wholesaler, distributor, and manufacturer, respectively. (Note that the variance of orders equals the variance of demand for that firm's supplier.)
a) Calculate the bullwhip measure for the retailer.
b) Calculate the bullwhip measure for the wholesaler.
c) Calculate the bullwhip measure for the distributor.
d) Calculate the bullwhip measure for the manufacturer.
e) Which firm appears to be contributing the most to the bull-whip effect in this supply chain?

•• **S11.7**   Over the past 5 weeks, demand for wine at Winston's Winery has been 1,000, 2,300, 3,200, 1,750, and 1,200 bottles. Winston has placed weekly orders for glass bottles of 1,100, 2,500, 4,000, 1,000, and 900 units. (Recall that the sample vari-ance of a data set can be found by using the VAR.S function in Excel or by plugging each x value of the data set into the

formula: Variance $= \dfrac{\Sigma(x - \bar{x})^2}{(n - 1)}$, where $\bar{x}$ is the mean of the

data set and n is the number of values in the set.)

a) What is the variance of demand for Winston's Winery?
b) What is the variance of orders from Winston's Winery for glass bottles?
c) What is the bullwhip measure for glass bottles for Winston's Winery?
d) Is Winston's Winery providing an amplifying or smoothing effect?

•• **S11.8**   Over the past 12 months, Super Toy Mart has expe-rienced a demand variance of 10,000 units and has produced an order variance of 12,000 units.
a) What is the bullwhip measure for Super Toy Mart?
b) If Super Toy Mart had made a perfect forecast of demand over the past 12 months and had decided to order 1/12 of that annual demand each month, what would its bullwhip measure have been?

••• **S11.9** Consider a three-firm supply chain consisting of a retailer, manufacturer, and supplier. The retailer's demand over an 8-week period was 100 units each of the first 2 weeks, 200 units each of the second 2 weeks, 300 units each of the third 2 weeks, and 400 units each of the fourth 2 weeks. The following table pre-sents the orders placed by each firm in the supply chain. Notice, as is often the case in supply chains due to economies of scale, that total units are the same in each case, but firms further up the supply chain (away from the retailer) place larger, less frequent, orders.

Supplement 11 *Rapid* Review

Main Heading	Review Material	MyOMLab
TECHNIQUES FOR EVALUATING SUPPLY CHAINS (p. 472)	Many supply chain metrics exist that can be used to evaluate performance within a company and for its supply chain partners.	Concept Question: 1.1
	The 2011 Tōhoku earthquake and tsunami devastated eastern sections of Japan. The economic impact was felt around the globe, as manufacturers had been relying heavily, in some cases exclusively, on suppliers located in the affected zones. Manufacturers in several industries worldwide took 6 months or longer before they saw their supply chains working normally again.	

| Main Heading	Review Material	MyOMLab
EVALUATING DISASTER RISK IN THE SUPPLY CHAIN (pp. 472–474)	Disasters that disrupt supply chains can take on many forms, including tornadoes, fires, hurricanes, typhoons, tsunamis, earthquakes, and terrorism.	Concept Questions: 2.1–2.4
	Firms often use multiple suppliers for important components to mitigate the risks of total supply disruption. *The probability of all* n *suppliers being disrupted simultaneously*:	Problems: S11.1–S11.5
	$$P(n) = S + (1 - S)U^n \qquad \text{(S11-1)}$$	Virtual Office Hours for Solved Problem: S11.1
	where: S = probability of a "super-event" disrupting all suppliers simultaneously U = probability of a "unique-event" disrupting only one supplier L = financial loss incurred in a supply chain if all suppliers were disrupted C = marginal cost of managing a supplier	
	All suppliers will be disrupted simultaneously if either the super-event occurs or the super-event does not occur but a unique-event occurs for all of the suppliers.	
	As the probability of a super-event (S) increases, the advantage of utilizing multiple suppliers diminishes (all would be knocked out anyway). On the other hand, large values of the unique event (U) increase the likelihood of needing more suppliers.	
	These two phenomena taken together suggest that when multiple suppliers are used, managers may consider using ones that are geographically dispersed to lessen the probability of all failing simultaneously.	
	A decision tree can be used to help operations managers make this important decision regarding number of suppliers.	
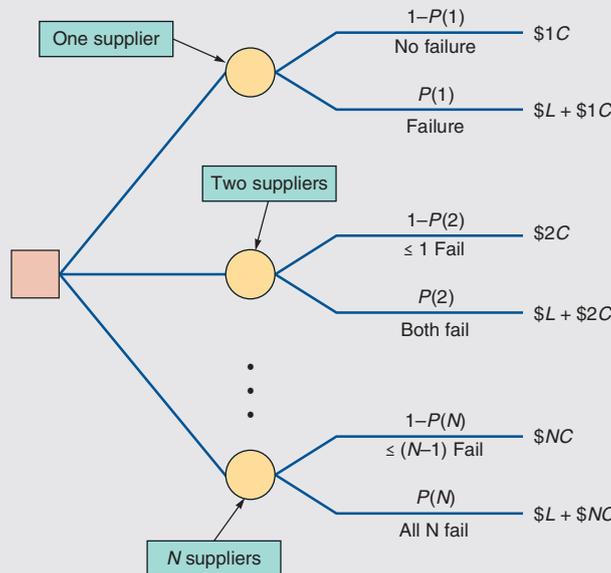
Main Heading	Review Material	MyOMLab
MANAGING THE BULLWHIP EFFECT (pp. 474–476)	*Demand forecast updating, order batching, price fluctuations*, and *shortage gaming* can all produce inaccurate information, resulting in distortions and fluctuations in the supply chain and causing the *bullwhip effect*.	Concept Questions: 3.1–3.4
	■ **Bullwhip effect**—The increasing fluctuation in orders that often occurs as orders move through the supply chain.	Problems: S11.6–S11.9
	"Bullwhip" fluctuations create unstable production schedules, resulting in expensive capacity change adjustments such as overtime, subcontracting, extra inventory, backorders, hiring and laying off of workers, equipment additions, equipment underutilization, longer lead times, or obsolescence of overproduced items. The bullwhip effect can occur when orders decrease as well as when they increase. Often the human tendency to overreact to stimuli causes managers to make decisions that exacerbate the phenomenon.	Virtual Office Hours for Solved Problem: S11.2

Main Heading	Review Material	
	The overarching solution to the bullwhip effect is simply for supply chain members to share information and work together.	
	Specific remedies for the four primary causes include:	
	Demand forecast errors $\rightarrow$ *Share demand information throughout the chain*	
	Order batching $\rightarrow$ *Think of the supply chain as one firm when choosing order sizes*	
	Price fluctuations $\rightarrow$ *Institute everyday low prices*	
	Shortage gaming $\rightarrow$ *Allocate orders based on past demand*	
	A straightforward way to measure the extent of the bullwhip effect at any link in the supply chain is to calculate the *bullwhip measure*:	
	$$\text{Bullwhip} = \frac{\text{Variance of orders}}{\text{Variance of demand}} = \frac{\sigma^2_{\text{orders}}}{\sigma^2_{\text{demand}}} \qquad \text{(S11-2)}$$	
	Variance *amplification* (i.e., the bullwhip effect) is present if the bullwhip measure is greater than 1. That means the size of a company's orders fluctuate more than the size of its incoming demand. If the measure equals 1, then no amplification is present. A value less than 1 would imply a *smoothing* or *dampening* scenario as orders move up the supply chain from the retailer toward suppliers.	
SUPPLIER SELECTION ANALYSIS (pp. 476–477)	Choosing suppliers simply based on the lowest bid has become a somewhat rare approach. Various, sometimes competing, factors often play a role in the decision. Buyers may consider such supplier characteristics as product quality, delivery speed, delivery reliability, customer service, and financial performance. The *factor-weighting* technique simultaneously considers multiple supplier criteria. Each factor must be assigned an importance *weight*, and then each potential supplier is *scored* on each factor. The weights typically sum to 100%. Factors are scored using the same scale (e.g., 1–10). Sometimes a key is provided for supplier raters that converts qualitative ratings into numerical scores (e.g., "Very good" = 8).	Concept Questions: 4.1–4.2 Problems: S11.10–S11.11, S11.13 Virtual Office Hours for Solved Problem: S11.3
TRANSPORTATION MODE ANALYSIS (pp. 477–478)	The longer a product is in transit, the longer the firm has its money invested. But faster shipping is usually more expensive than slow shipping. A simple way to obtain some insight into this trade-off is to evaluate holding cost against shipping options. *Daily cost of holding the product*: (Annual holding cost $\times$ Product value)/365 There are many other considerations beyond holding vs. shipping costs when choosing the appropriate transportation mode and carrier, including ensuring *on-time delivery* (whether fast or slow), coordinating shipments to maintain a schedule, getting a new product to market, and keeping a customer happy. Estimates of these other costs can be added to the estimate of the daily holding cost.	Concept Questions: 5.1–5.2 Problems: S11.14–S11.17 Virtual Office Hours for Solved Problem: S11.4
WAREHOUSE STORAGE (pp. 478–479)	When determining storage locations for items in a warehouse, rank the items according to the ratio: (Number of trips/Blocks of storage needed) Place the items with the *highest* ratios closest to the dock.	Concept Questions: 6.1–6.2 Problems: S11.18–S11.20

Self Test

■ **Before taking the self-test,** refer to the learning objectives listed at the beginning of the supplement.

LO S11.1 Which of the following combinations would result in needing to utilize the largest number of suppliers?
 a) a high value of S and high value of U
 b) a high value of S and low value of U
 c) a low value of S and high value of U
 d) a low value of S and low value of U

LO S11.2 Typically, the bullwhip effect is most pronounced at which level of the supply chain?
 a) consumers   **b)** suppliers
 c) wholesalers   **d)** retailers

LO S11.3 Which of the following is not a characteristic of the factor-weighting approach to supplier evalution?
 a) it applies quantitative scores to qualitative criteria
 b) the weights typically sum to 100%
 c) multiple criteria can be considered simultaneously
 d) subjective judgment is often involved
 e) it applies qualitative assessments to quantitative criteria

LO S11.4 A more expensive shipper tends to provide:
 a) faster shipments and lower holding costs
 b) faster shipments and higher holding costs
 c) slower shipments and lower holding costs
 d) slower shipments and higher holding costs

LO S11.5 Which of the following items is most likely to be stored at the back of a warehouse, furthest away from the shipping dock?
 a) low number of trips and low number of storage blocks
 b) low number of trips and high number of storage blocks
 c) high number of trips and low number of storage blocks
 d) high number of trips and high number of storage blocks

Answers: LO S11.1. c; LO S11.2. b; LO S11.3. e; LO S11.4. a; LO S11.5. b.