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## CHAPTER 10

# Supply Chain Management Strategy and Design



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### LEARNING OBJECTIVES

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**After reading this chapter, you will be able to:**

- Describe the key characteristics and management strategies of the modern supply chain.
- Discuss sustainable supply chain practices and the impact of the environment on supply chain decisions.
- Describe the role of information technology in supply chains, and the need for supply chain integration.
- Present the SCOR model and calculate key performance indicators for monitoring supply chain performance.

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# Smartphone Supply Chain Strategies at Samsung and Apple

Together Samsung and Apple account for about half of all smartphones sold around the world. A key ingredient in their success is each company's management of an efficient supply chain. In Gartner's annual ranking of the top 25 supply chains, Apple is one of two companies (with Procter and Gamble) in a special "Masters" category achieved because they have been ranked in the top five for at least 7 out of 10 years; and Samsung consistently ranks in the top 10. Their supply chains consist of a vast network of suppliers that manufacture and ship the ever-increasing and complicated number of components in smartphones. Every day billions of smartphone components are being shipped around the world. With annual global smartphone sales of over 1.2 billion, the number of components being manufactured and shipped each year is enormous, almost a trillion. This number will continue to increase as smartphones and other mobile devices become even more complex and sophisticated, as will the importance of a well-managed supply chain. However, managing a global supply chain is filled with the risk of delays and there are numerous and frequent examples of delayed product launches that resulted in lost sales and reduced market share. At Google, supply chain issues affected the availability of a version of its flagship Nexus smartphone, causing critical shortages at its launch, and HTC experienced significant device shortages because its phone camera component suppliers had inaccurate product and component forecasts.

It is apparent that Apple and Samsung gain an advantage over their competitors from their superior supply chains and their efficient management of billions of components, although each company does it quite differently. Most of Samsung's supply chain is in-house, from product development to final assembly, and it only uses suppliers (that are easily replaceable) for low-cost components. Also, Samsung is the largest manufacturer in its region, which gives it bargaining power and flexibility with its suppliers to increase or decrease the size of its orders, which in turn reduces inventory costs. Alternatively, Apple outsources almost

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all of its manufacturing. It has almost 750 suppliers, over 600 in Asia, which Apple closely monitors. Apple does not offer as many smartphone variations as Samsung, which allows them to focus on the supply of fewer components. Apple also has the highest loyalty rate in the smartphone industry, giving it significant bargaining power with its manufacturing suppliers.

A new smartphone model will include unique and perhaps exclusive components that create risk and uncertainty in the supply chain, requiring suppliers who have the needed capacity and are willing and able to steadily supply these components before, during, and after the product launch. A Samsung Galaxy smartphone has over a thousand component parts and major components often have many subcomponents, which can also be made up of subcomponents. And while the number of components and capabilities of devices have increased, the relative size of these devices has decreased, making the manufacturing process more complex than ever. The supply of these many hundreds of individual parts takes significant time, resources, and technical expertise. It's not surprising that timing is crucial to any smartphone's success in the market. Delays in any part of the supply chain, from raw materials to manufacturing, can significantly affect commercial success. Samsung and Apple, with two different strategies, have built reliable and consistently excellent supply chains that are the industry's best, which enable them to manage a steady stream of billions of components, meet customer demand, and thwart competitors from eating into their combined market share.

In this chapter we will learn about supply chains and the key role supply chain management plays in successfully integrating all the operations and processes involved in producing a product like smartphones.

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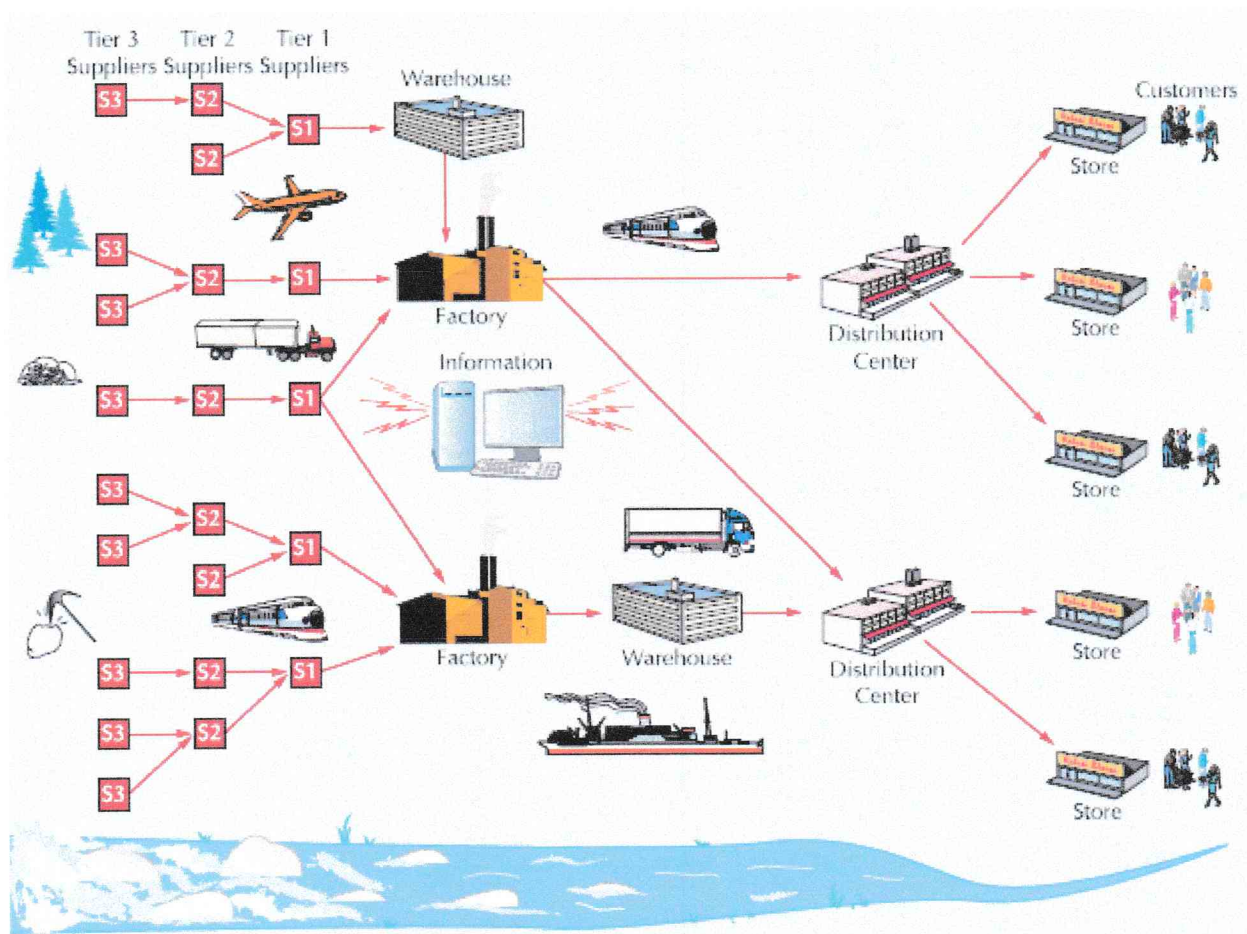
## Supply Chains

Globalization and the evolution of information technology have provided the catalysts for supply chain management to become the strategic means for companies to manage quality, satisfy customers, and remain competitive. A **supply chain** encompasses all activities associated with the flow and transformation of goods and services from the raw materials stage to the end user (customer), as well as the associated information flows. In essence, it is all the assets, information, and processes that provide "supply." It is made up of many interrelated members, starting with raw material suppliers, and including parts and components suppliers, subassembly suppliers, the product or service producer, and distributors, and ending with the end-use customer.

**Supply chain** The facilities, functions, and activities involved in producing and delivering a product or service from suppliers (and their suppliers) to customers (and their customers).

**Figure 10.1** illustrates the stages, facilities, and physical movement of products and services in a supply chain. The supply chain begins with suppliers, which can be as basic as raw material providers. These suppliers are referred to as upstream supply chain members, while the distributors, warehouses, and eventual end-use customers are referred to as downstream supply chain members. The stream at the bottom of the figure denotes the flow of goods and services (i.e., demand) as the supply chain moves downstream. Notice that the stream is very rough at

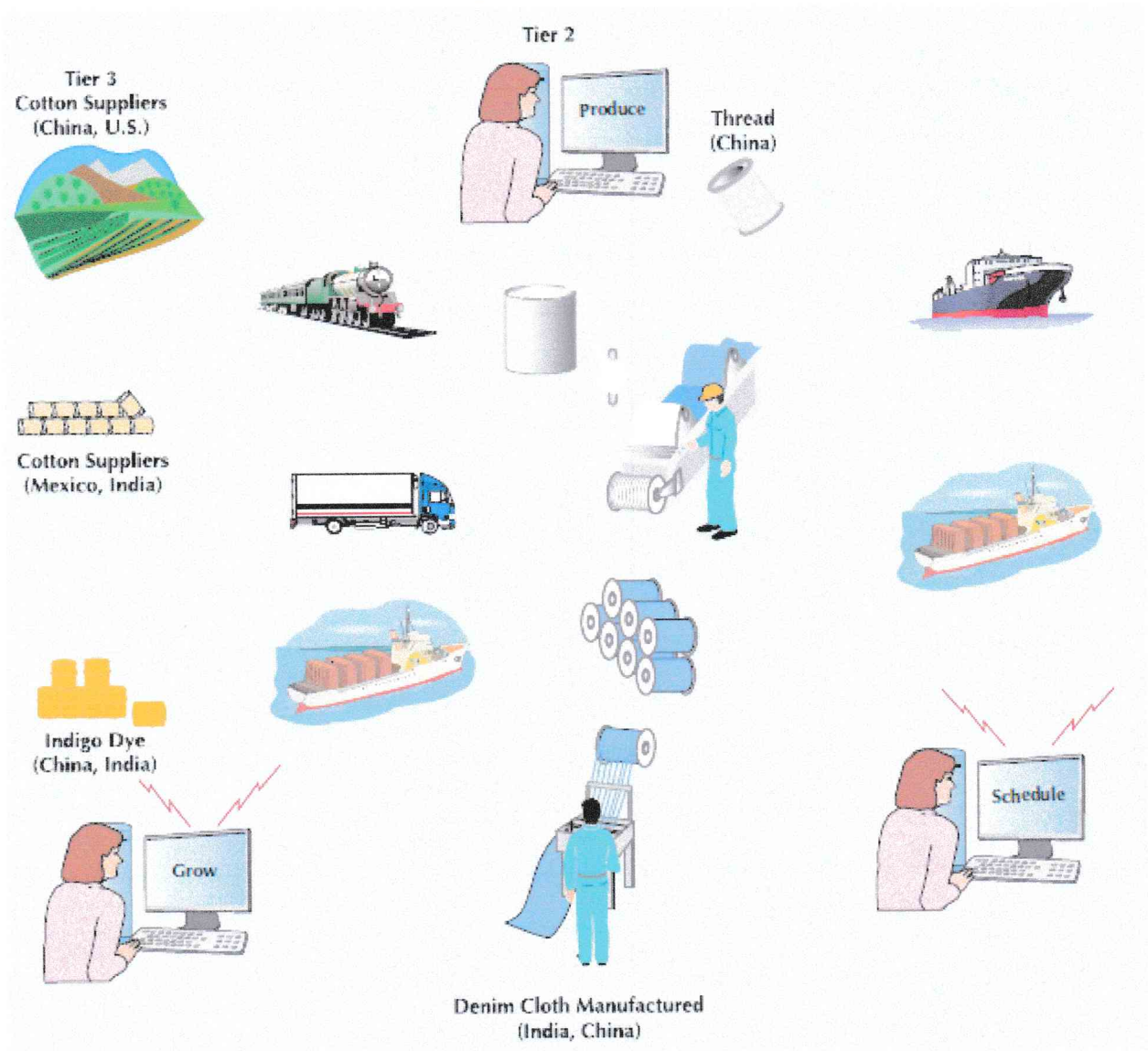
the upstream end and gets smoother as it moves downstream, a characteristic we will discuss in greater detail later. Also note that “information” is at the center of [Figure 10.1](#); it is the “heart and brains” of the supply chain, another characteristic we will talk more about later.

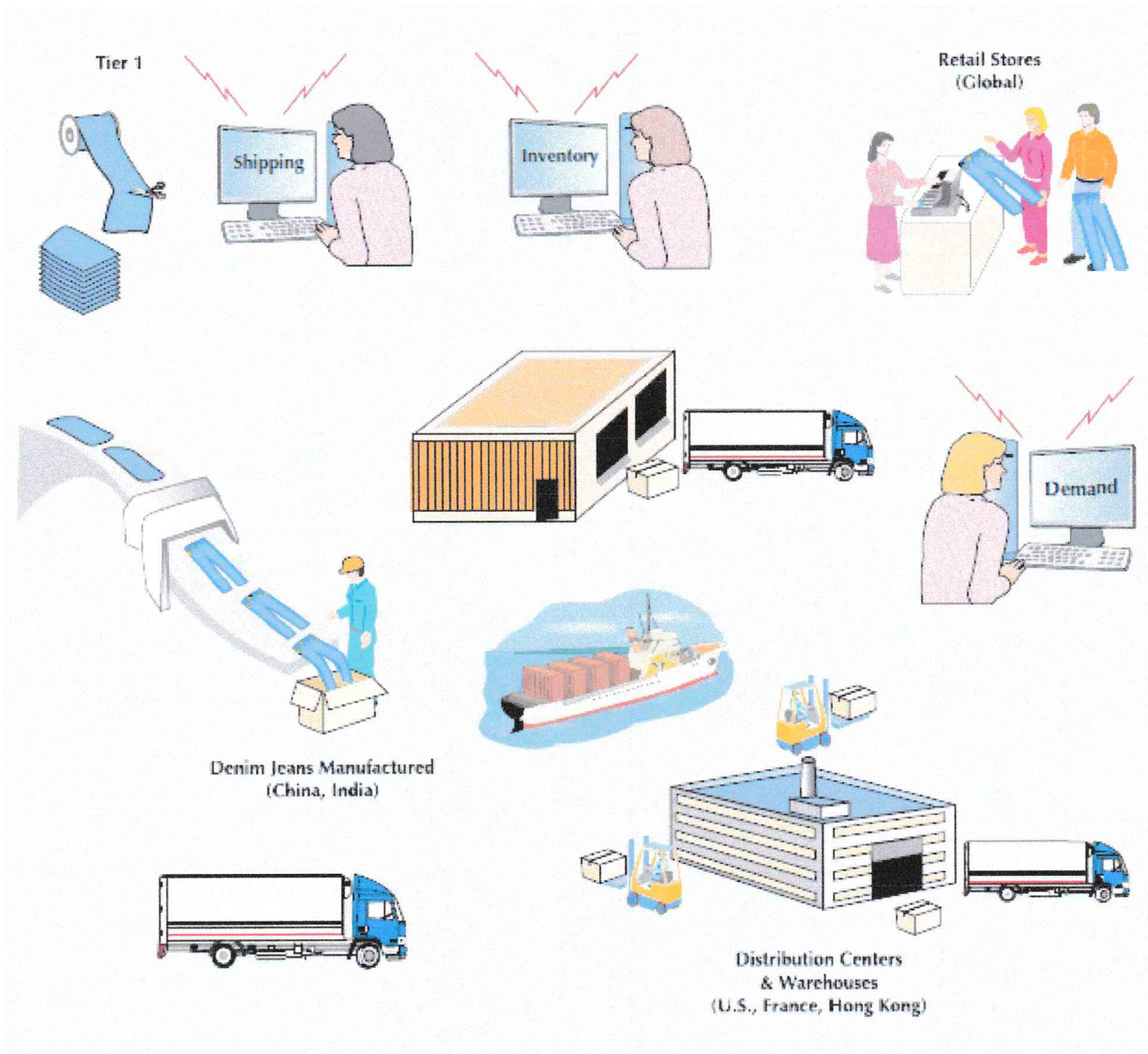


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### FIGURE 10.1 The Supply Chain

The supply chain in [Figure 10.1](#) can represent a single producer directly linked to one level of suppliers and one set of end-use customers. A grocery store that gets food products like milk, eggs, or vegetables directly from a farmer (and not through a distributor) and sells them directly to the customer who consumes them reflects this basic level of supply chain. However, supply chains are more typically a series of linked suppliers and customers; every customer is in turn a supplier to the next, up to the final end user of the product or service. For example, [Figure 10.2](#) shows the supply chain for denim jeans, a straightforward manufacturing process with a distinct set of suppliers. Notice that the jeans manufacturer has suppliers that produce denim who in turn have suppliers who produce cotton and dye.





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## FIGURE 10.2 The Supply Chain for Denim Jeans

As [Figures 10.1](#) and [10.2](#) show, the delivery of a product or service to a customer is a complex process, encompassing many different interrelated processes and activities. First, demand for a product or service is forecast, and plans and schedules are made to meet demand within a time frame. The product or service can require multiple suppliers (who have their own suppliers) who prepare and then ship parts and materials to manufacturing or service sites. A large manufacturer like Procter & Gamble has over 80,000 suppliers including first-tier suppliers that supply it directly, second-tier suppliers that supply those suppliers, third-tier suppliers that supply second-tier suppliers, and so on. Parts and materials are transformed into final products or services. These products may then be stored at a distribution center or warehouse. Finally, these products are transported by carriers to external or internal customers. However, this may not be the final step at all, as these customers may transform the product or service further and ship it on to their customers. All of this is part of the supply chain—that is, the flow of goods and services from the materials stage to the end user.

The supply chain is also an integrated group of business processes and activities with the same goal—providing customer satisfaction. As shown in [Figure 10.3](#), these processes include the **procurement** of services, materials, and components from suppliers; production

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of the products and services; and distribution of products to the customer including taking and filling orders. Information and information technology tie these processes together; it is what “integrates” them into a supply chain.

**procurement** Purchasing goods and services from suppliers.

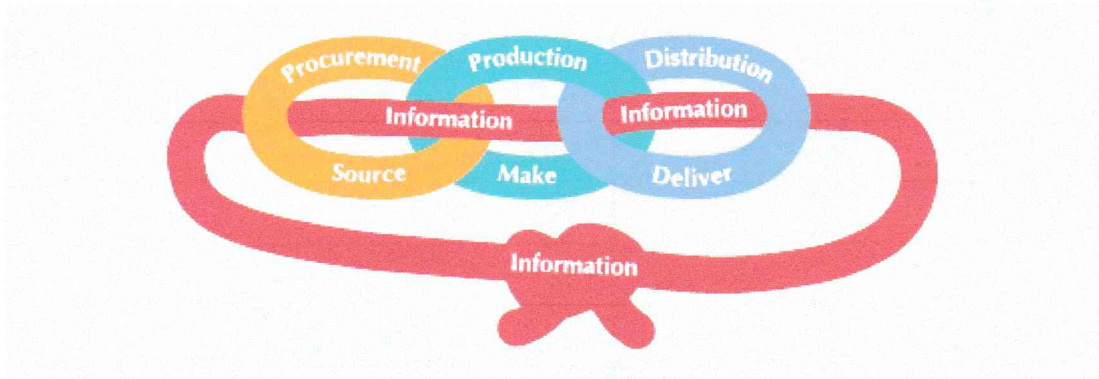


FIGURE 10.3 Supply Chain Processes

## Supply Chains for Service Providers

Supply chains for services are sometimes not as easily defined as supply chains for manufacturing operations. Since the supply chain of a service provider does not always provide the customer with a physical good, its supply chain does not focus as much on the flow of physical items (material, parts, and subassemblies) through the supply chain. It instead may focus more on the human resources and support services necessary to provide its own service. The supply chain of a service provider also tends to be more compact and less extended than a manufacturing supply chain. It generally does not have as many tiers of suppliers, and its distribution network is smaller or nonexistent. However, supply chains of service companies are definable and can be effectively managed using many of the same principles. Service companies and organizations have suppliers (who have suppliers), and they distribute their products to customers (who may have their own customers). Although a hospital and HMO do not provide actual goods to its customers, they nevertheless purchase equipment, computers, drugs, and medical supplies from suppliers (who have suppliers). They also contract for services (such as food preparation or laundry); hire doctors, nurses, accountants, administrators, and staff; and provide healthcare. They have quality-management issues throughout their supply chain. They also encounter the same problems and inefficiencies as a manufacturing-based supply chain. Other service-oriented companies, like McDonald’s, do, in fact, provide a physical product, and thus have a more discernible supply chain with distribution, transportation, and inventory like a manufacturing company.

## Value Chains

In recent years, terms such as value chain and demand-driven value chain have entered the supply chain lexicon and are sometimes used instead of, or interchangeably with, supply chain.

Are there any differences among the various terms? The traditional view of a supply chain was that it focused somewhat narrowly on the activities and processes associated with material management and logistics that convert raw materials and subassemblies into a manufactured product—plan, source, make, and deliver. However, a **value chain** is thought to have a broader focus with a more important and visible corporate presence that might also include such functions as customer management, new product innovation and launch, post-sales support and change management. In this context, the ultimate goal of a value chain is the delivery of maximum value to the end user.

**Value chain** A more contemporary name for a supply chain.

A demand-driven value chain is considered to be a global supply chain that is organized according to three overlapping areas of responsibility:

- Supply management—manufacturing, logistics, supply planning, and sourcing
- Demand management—marketing, sales, demand planning, and service
- Product management—R&D, innovation, engineering, and product development

When these processes work together, are visible to each other, and communicate, then a company can respond quickly and efficiently to opportunities that arise from customer or market demand (i.e., it is demand-driven, and thus creates value for all parts of the supply chain). Key features of this vision of a supply chain are operational and innovation excellence. Operational excellence delivers products to customers as promised; while innovation excellence makes sure customers want what's being made and shipped by embedding innovation within operations and not isolating it in a lab.

However, the general “current” perception of a supply chain is that it also encompasses this same broad focus. The objective of supply chain management is to increase value for any part or all of the chain. In reality, all of these names have come to mean approximately the same thing to most people, and the terms are frequently used interchangeably—a supply chain is a demand-driven value chain, and vice versa.

A common thread among these perceptions of supply, value, and demand chains is that of **value**. Value to the customer is good quality, a fair price, and fast and accurate delivery. To achieve value for the customer, the members of the supply chain must act as partners to systematically create value at every stage of the supply chain. Thus, companies not only look for ways to create value internally in their own production processes, but they also look to their supply chain partners to create value by improving product design and quality, enhancing supply chain performance and speed, and lowering costs. To accomplish these value enhancers, supply chain members must collaborate with each other and integrate their processes, topics that we will continually return to in this chapter.

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## Along the Supply Chain

### The Denim Jeans Supply Chain

The United States is the world's largest market for denim jeans. Out of the 2 billion pairs of jeans sold each year worldwide about 40% are sold in the United States. The favorite jeans of consumers are U.S. brands such as Levi's, Lee, Wrangler, Gap, Old Navy, and American Eagle. However, almost all denim jeans sold in U.S. stores (approximately 98%), are imported from suppliers in countries around the world, even though the United States is the world's third largest cotton producer and the largest cotton exporter. This means that the denim jeans industry encompasses a supply chain that is geographically and financially one of the largest in the world, with the United States as a major (cotton) supplier on one end of the supply chain, the predominant jeans consumer on the other end, but with virtually none of the production process in between. China, India, the United States, and Pakistan produce almost 80% of the world's cotton. Much of the cotton grown in China, India, and Pakistan supply manufacturing facilities within these countries that produce denim cloth and then jeans, while cotton from the United States (as well as other major exporters like India, Brazil, and Australia) is exported to these countries as well as other major denim fabric and jeans producing countries like Mexico and Bangladesh. China, Mexico, and Bangladesh are the top jeans suppliers to the United States, accounting for almost 70% percent of U.S. imports. Mexico is the largest U.S. supplier of men's and boy's jeans (approximately 40%) while China is the primary supplier for women's and girl's jeans (about 44% percent). The jeans manufacturing process can occur at facilities entirely within a country or between countries. For example, cotton grown in the United States, can be shipped to China where it is stored in warehouses, then transported by truck or rail to a Chinese facility where it is spun into yarn, which is then shipped to another city in China where denim cloth is produced, which is then shipped to Bangladesh where jeans are sewn, and buttons, rivets, and zippers are added from other plants before the finished denim jeans are shipped back to the United States to complete the supply chain.

Discuss how the supply chain for a product like denim, which is somewhat straightforward and simple, differs from a supply chain for a more complex product like smartphones.

Sources: Based on "Denim Jeans: State of the U.S. Market," [www.lifestylemonitor.cottoninc.com](http://www.lifestylemonitor.cottoninc.com), 2011; and, Summer R. Oakes, "Textile Talk: DenimNation-Series 1.1" [www.source4style.com](http://www.source4style.com), 2011.

## The Management of Supply Chains

**Supply chain management (SCM)** focuses on integrating and managing the flow of goods and services and information through the supply chain in order to make it responsive to customer needs while lowering total costs. Traditionally, each segment of the supply chain was managed as a separate (stand-alone) entity focused on its own goals. However, to compete in today's global marketplace a company has to count on the combined and coordinated effort of all members of the supply chain.

**Supply chain management (SCM)** Requires managing the flow of information through the supply chain in order to attain the level of synchronization that will make it more responsive to customer needs while lowering costs.

Supply chains require close collaboration, cooperation, and communication among members to be effective. Suppliers, and their customers must share information. It is the rapid flow of information among customers, suppliers, distributors, and producers that characterizes today's supply chain management. Suppliers and customers must also have the same goals. They need to be able to trust each other. Customers need to be able to count on the quality and timeliness of the products and services of their suppliers. Furthermore, suppliers and customers must participate together in the design of the supply chain to achieve their shared goals and to facilitate communication and the flow of information.

## Supply Chain Uncertainty and Inventory

One of a company's main objectives in managing its supply chain is to synchronize the upstream flow of incoming materials, parts, subassemblies, and services with production and distribution downstream so that it can respond to uncertainty in customer demand without

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creating costly excess inventory. Examples of factors that contribute to uncertainty, and hence variability, in the supply chain are inaccurate demand forecasting, long variable lead times for orders, late deliveries, incomplete shipments, product changes, batch ordering, price fluctuations and discounts, and inflated orders. The primary negative effects of supply chain uncertainty and variability are lateness and incomplete orders. If deliveries from suppliers are late or incomplete, they slow down the flow of goods and services through the supply chain, ultimately resulting in poor-quality customer service. Companies cope with this uncertainty and try to avoid delays with their own form of “insurance,” **inventory**.

**Inventory** Insurance against supply chain uncertainty.

Supply chain members carry buffer (or extra) inventory at various stages of the supply chain to minimize the negative effects of uncertainty and to keep goods and services flowing smoothly from suppliers to customers. For example, if a parts order arrives late (or does not arrive at all) from a supplier, the producer is able to continue production and maintain its delivery schedule to its customers by using parts it has stored in inventory for just such an occurrence.

Companies also accumulate inventory because they may order in large batches in order to keep down order and transportation costs or to receive a discount or special price from a supplier. However, inventory is very costly. Products sitting on a shelf or in a warehouse are just like money sitting there not being used when it could be used for something else. It is estimated that the cost of carrying a retail product in inventory for one year is between 18% and 35% of what the item cost. Inventory-carrying costs are almost \$500 billion per year in the United States. As such, suppliers and customers would like to minimize or eliminate it.

## The Bullwhip Effect

Distorted information or the lack of information, such as inaccurate demand data or forecasts from the customer end can ripple back upstream through the supply chain and magnify demand variability at each stage. This can result in high buffer inventories, poor customer service, missed production schedules, wrong capacity plans, inefficient shipping, and high costs. This phenomenon, which has been observed across different industries, is known as the **bullwhip effect**. It occurs when slight to moderate demand variability becomes magnified as demand information is transmitted back upstream in the supply chain. In [Figure 10.1](#) the stream at the bottom of the figure reflects this occurrence; the flow is greater (and the waters more turbulent) further upstream. [Figure 10.4](#) presents a detailed perspective of the bullwhip effect.

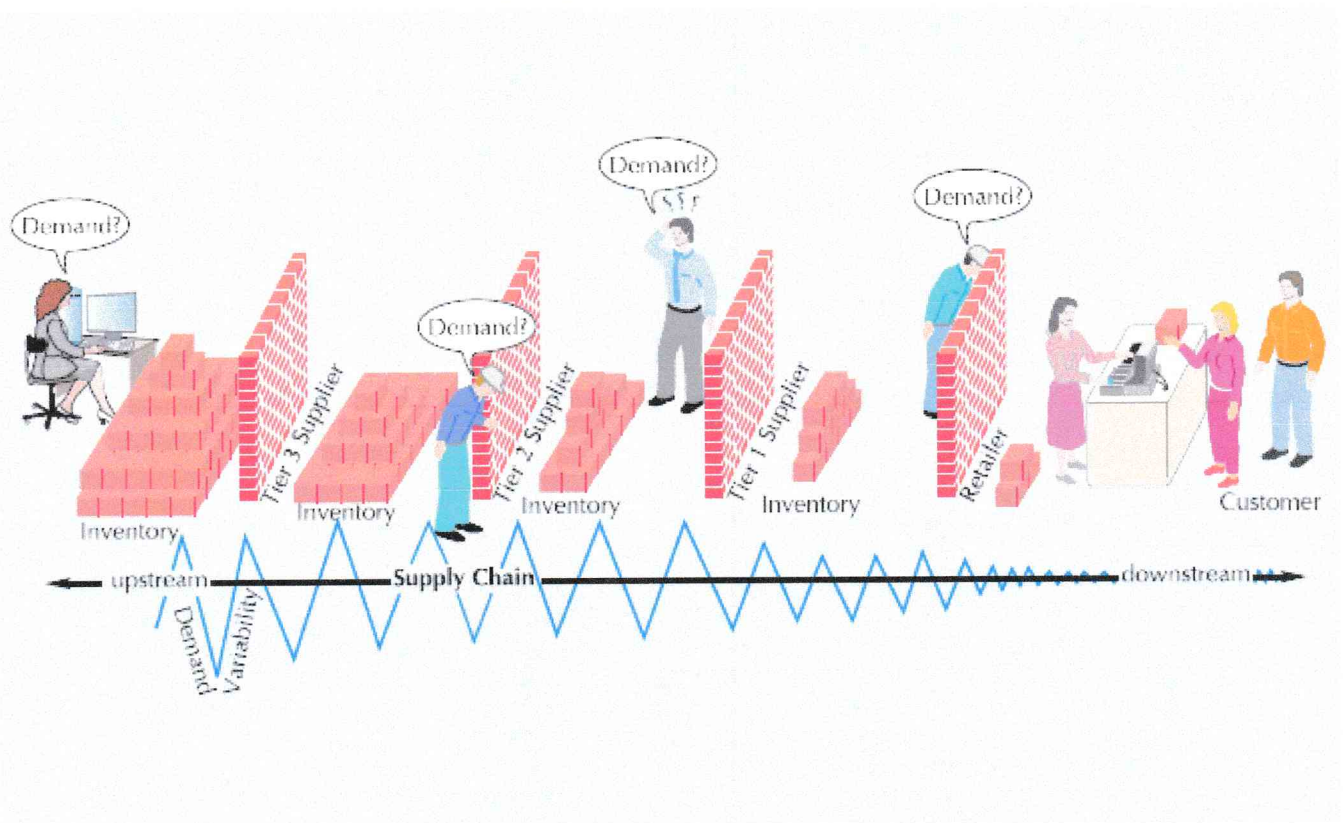


FIGURE 10.4 The Bullwhip Effect

**Bullwhip effect** Occurs when slight demand variability is magnified as information moves back upstream.

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The bullwhip effect is created when supply chain members make ordering decisions with an eye to their own self-interest and/or they do not have accurate demand information from the adjacent supply chain members. If each supply chain member is uncertain and not confident about what the actual demand is for the succeeding member it supplies and is making its own demand forecast, then it will stockpile extra inventory to compensate for the uncertainty. In other words, they create a security blanket of inventory. As shown in Figure 10.4, demand for the end user is relatively stable and the inventory is small. However, if slight changes in demand occur, and the distributor does not know why this change occurred, then the distributor will tend to overreact and increase its own demand, or conversely reduce its own demand too much if demand from its customer unexpectedly drops. This creates an even greater overreaction by the manufacturer who supplies the distributor and the suppliers who supply the manufacturer. One way to cope with the bullwhip effect is for supply chain members to share information, especially demand forecasts. If the supply chain exhibits transparency, then members can have access to each other's information, which reduces or eliminates uncertainty.

## Managing Supply Chain Risk

When supply chains stretch over long distances and multiple locations around the world, uncertainty, and therefore risk, increase. In “lean” supply chains there is little redundancy and slack (i.e., inventory), so when disruptions occur—natural or otherwise—the effects can cascade through the supply chain, slowing or stopping normal operations and eventual customer order fulfillment. As suggested previously, one way to offset uncertainty is by carrying extra inventory at various points along the supply chain, however, as we have also noted, this is an expensive solution for handling uncertainty and risk. Instead, a number of innovative companies with top supply chains have begun to engage in formal “risk management” to cope with supply chain uncertainty.

For the first time, risk is being incorporated into the latest version of ISO 9001:2015, which establishes the requirements of a quality management system (see the section on standards in Chapter 2). The ISO defines risk as “the effect of uncertainty on an expected result.” As part of the ISO 9001:2015 standard, organizations are required to determine the processes needed for a quality management system, which includes the identification of risks and the opportunities and actions needed to address them. Management is required to demonstrate leadership and commitment to customers by taking a risk-based approach, to make sure risks that affect products, services, and the ability to enhance customer satisfaction are identified and addressed.

Risk management requires due diligence to evaluate and anticipate the likelihood and possible impact of unexpected supply chain disruptions, which can be operational, economic, marketplace, or natural, and plan ahead for them. In recent years as a result of a global economic downturn and several natural disasters, including an earthquake in Japan, floods in Thailand, and a volcanic eruption in Iceland, companies have altered their approach to supply chain management to incorporate formal ongoing risk management processes to identify and plan for possible disruptions. This is referred to as building resiliency (or continuity) into the supply chain. (See the “Along the Supply Chain” for Cisco Systems.) These processes include identifying circumstances in advance that could cause disruptions, monitoring events worldwide to anticipate disruptions, and developing contingency plans for the occurrence of disruptions, including a pool of alternative suppliers, logistics providers, and energy sources to fall back on when disruptions occur. After the Japanese earthquake in 2011, one international automaker that sourced a microcontroller exclusively from a company in Japan had lined up an alternate

supplier as part of its proactive risk management contingency plan, which allowed the company to avoid being forced to cut production by half following the earthquake, and enabled it to return to normal operations within a few months.

However, risks do not just evolve from natural disasters. Risks are also inherent in a variety of potential operational issues including transportation and logistics disruptions; customer and supplier communication failures; product, processes, and supply chain design failures; changes in regulatory/customs documentation and environmental requirements; security issues and terrorism threats; data thefts and computer system breaches; marketplace changes; and supplier insolvency to name just a few of the many possible sources of risk.

**Risk pooling** is an approach to managing risks in which an attempt is made to aggregate risks to reduce the impact of individual risks. One way to pool risks is to combine inventories from multiple at-risk locations into a few, or one, location, like a warehouse or distribution center, in a more risk-free environment. It is well known that it is more economical to hold inventory at a single location than to disperse it across a number of customer locations. Doing so reduces the overall inventory investment needed to achieve a target service level across all the customers supplied by a distribution center, which, in effect, reduces demand variability. Adding a distribution center between a supplier and a customer can also shorten lead times, which is another way to pool risks (i.e., it's more costly to meet variations in demand from several locations than from one).

**Risk pooling:** An approach to risk management that aggregates risk to reduce its impact.



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The devastation in Northeast Japan following a major earthquake and tsunami that hit the island in March 2011. For months this natural disaster disrupted the global supply chains of many companies with Japanese suppliers.

Another way to manage risks is to build risk tradeoffs into product and service designs to include fewer parts and product variability. Reducing the number of product components

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allows a company to meet demand with fewer products and fewer suppliers. Having common product components that can be used in a lot of different products enables a company to pool its forecasts for component demand, resulting in fewer demand forecasts. (The more forecasts, the more chances for errors.) Reducing product offerings can have the same effect—it's easier to forecast demand for a smaller number of product configurations than a larger number.

## Along the Supply Chain

### Supply Chain Resiliency at Cisco Systems

Cisco Systems, the San Jose-based designer and manufacturer of networking equipment with annual revenues over \$47 billion, outsources all of the manufacturing of its products. It has a global supply chain of more than 600 direct suppliers and numerous manufacturing partners that supply around 80,000 parts for its products. Its supply chain was ranked sixth best in Gartner's 2015 annual Top 25 ranking of company's supply chains. Following Hurricane Katrina in 2005, Cisco found that it was not capable of responding quickly and effectively enough to meet demand from its customers for \$1 billion in telecommunication replacement parts in the Gulf Coast region. As a result, Cisco created a centralized risk management team within its supply chain operations organization that works with other organizational functions (like engineering and customer operations) to ensure supply chain resiliency in the face of possible disruptions. Cisco achieves resiliency through four processes. Product resiliency identifies strategic priorities for product categories and determines risk trade-offs early in the development and sourcing of products. Supply chain resiliency identifies supply chain vulnerabilities and mitigates circumstances that could limit recovery from a major disruption within a certain time frame. Business continuity planning compiles resiliency data points for critical suppliers including such things as emergency contacts, alternate power providers, and estimated recovery time as part of the supply chain design process. The supply chain incident management process monitors events worldwide on a 24/7 basis for any potential disruption that could impact suppliers, transportation, or manufacturing. In 2011, six years after the lessons learned from Hurricane Katrina these processes helped Cisco weather the Japanese earthquake that impacted over 7000 parts and involved 300 suppliers. Cisco was able to execute 900 new supply sources three times faster than the average time and incurred only minimal customer order fulfillment disruption and virtually no loss of revenue. Cisco was also able to react to similar natural disruptions, including floods in Thailand and an Iceland volcano eruption, due to its supply chain resiliency processes.

Do you think Cisco's centralized approach to risk management would be appropriate and useful for retail companies like P&G and Walmart?

Sources: Based on Mary Siegfried, "Building a Resilient Supply Chain," *Inside Supply Chain Management*, ([www.ism.ws](http://www.ism.ws)), 23 no. 3, April 2012, p. 24; and, Maria Jesus Saenz and Elena Revilla, "Creating More Resilient Supply Chains," *MIT Sloan Management Review*, ([www.sloanreview.mit.edu](http://www.sloanreview.mit.edu)), Summer 2014.

# Supply Chain Sustainability

Achieving **sustainability**, also referred to as “going green,” has become one of the most visible recent trends in operations and supply chain management. Sustainability, according to the United Nations, is “meeting present needs without compromising the ability of future generations to meet their needs.” Implicit in this definition is not depleting or abusing our natural resources like air, water, land, and energy in a way that’s going to harm current or future generations. For businesses it also means sustaining human and social resources. However, to many companies, sustainability means becoming environmentally friendly and socially conscious (i.e., “green”) at the expense of competitiveness and higher costs. A common perception among many U.S. and European corporations is that requiring suppliers, especially in developing countries, to use green practices is not feasible because they do not face the same governmental, cultural, and social pressures; that green manufacturing will require costly new equipment and processes; and that the customer market for products designed with green attributes is “soft.” As a result, companies often view social and environmental responsibility separately from business objectives.

**sustainability** Meeting present needs without compromising the ability of future generations to meet their needs.

## Along the Supply Chain

### Walmart's Commitment to Sustainability

Walmart is the world's largest company by revenue (over \$480 billion annually) and also the largest retailer, with over 11,500 retail locations in 28 countries. Walmart has more than 2.2 million employees around the world and has a global supply chain with over 100,000 suppliers. The company has made a major commitment to have an environmentally sustainable supply chain to make a difference for the environment and communities around the world. It has established corporate sustainability goals “to be supplied 100 per-cent by renewable energy, create zero waste, and sell products that sustain people and the environment.” To achieve these goals Walmart closely monitors and scrutinizes the environmental performance of its extended supply chain, suggests improvements to its suppliers, and helps its suppliers implement sustainable solutions. Walmart employs a sustainability index that measures supplier performance related to energy and climate, material efficiency, natural resources, and ethical production. The index helps Walmart direct its suppliers on what they need to be doing to meet the company's sustainability goals. Over 1,300 U.S. suppliers, representing 65% of the goods sold in Walmart stores, use the sustainability index to drive sustainable production.

Walmart has developed a number of sustainability initiatives, including a goal to eliminate 20 million metric tons of greenhouse gas (GHG) emissions (the amount of its direct emissions in 2010) from its global supply chain by 2016. By 2014 Walmart had over 335 renewable energy projects around the world that provided its facilities with over 2.2 billion kilowatt hours of electricity. The U.S. Environmental Protection Agency (EPA) ranks Walmart as the sixteenth-largest onsite green power generator in the United States. Combined with other renewable energy sources, in 2015 Walmart generated over 26% of its global electricity needs with renewable energy. The company procured over 3 billion kWh

globally achieving about 43% of its goal of procuring 7 billion kWh by 2020. Another energy initiative is to double Walmart's distribution fleet efficiency from a 2005 baseline by working with suppliers to use fuel-saving technologies and better driving techniques, and to load trucks more efficiently, improve routing, and use alternatively fueled trucks. It has committed to sending zero waste to U.S. landfills by 2025. In 2015 the company kept almost 82% of all waste from its U.S. operations and 68% internationally out of landfills, which had the potential to reduce CO<sub>2</sub> emissions by over 12 million tons annually.

In 2009 Walmart joined with several other companies that provided seed money to start The Sustainability Consortium (TSC), jointly run by the University of Arkansas and Arizona State University, that now includes over 100 of the world's largest retailers and consumer products companies including Coca-Cola, Pepsico, P&G, and Kellogg's. The consortium determines what makes certain products more sustainable than others and has developed guidelines for sustainability for over 100 product categories. In an effort to make its customers more sustainability conscious, Walmart's ecommerce (virtual) site now labels over 3000 products made by more than 100 of its suppliers with a badge reading "Made by a Sustainability Leader."

Identify the top five companies that are on the EPA's list of the top onsite green power generators and discuss their sustainability initiatives.

Sources: Based on the Walmart website at <http://corporate.walmart.com/global-responsibility/>; and Erica Plambeck and Lyn Denend, "The Greening of Walmart's Supply Chain ... Revisited," Supply Chain Management Review, 5 (September/October 2011), pp. 16–23.

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However, there is a growing realization among many companies that the social and environmental benefits of developing sustainable products do not have to come at the expense of reduced profits and competitiveness. In an IBM survey of 320 global companies in 31 countries, almost 37% indicated that they were utilizing sustainability as part of their company's innovation and growth strategy. As these companies have learned, sustainability can, in fact, be cost-effective and profitable and provide the impetus for product and process innovations. Green initiatives can lower costs because fewer resources are used, and additional revenues can result from better products or new businesses. Although Toyota realized huge costs in developing its hybrid Prius, it created a whole new successful and potentially profitable product and market just as gasoline prices were rising. Further, by designing products that can be recycled or reused, companies can reduce waste, thereby lowering costs. Thus, while a commitment to green practices can create a better image for companies among consumers (and the government), they can also reduce costs and increase revenues.

The impetus for, and commitment to, sustainability generally comes from downstream in the supply chain and moves back upstream to include suppliers. Companies have found that suppliers can account for as much as 80% of the resources consumed in a product's supply chain. Companies must work with and guide suppliers to reduce the inefficient use of resources, reduce the use of raw materials, reduce waste, and recycle. Suppliers can be coerced into using green practices by threats, demands, or incentives, or a combination.

## Sustainability and Quality Management

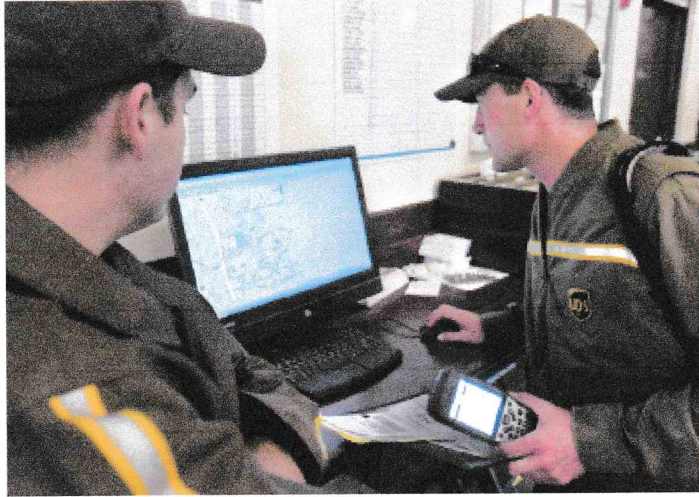
Many companies already have quality improvement programs in place that require suppliers to adhere to continuous improvement goals of eliminating returned products, thus reducing waste; poor quality translates to wasted resources. The same quality management focus on reducing waste can work to achieve sustainability goals. As we discussed in Chapter 2, the cost of poor quality can have a significant impact on a company's profitability and competitiveness, and quality costs may often come from suppliers along the supply chain, including the cost of materials, labor, and resources for reworking defective products; the cost of shipping delays and customer service errors; and the cost of product replacement and waste.

Improving fuel efficiency in a distribution fleet, having employees telecommute, using eco-friendly packaging materials, building energy efficient facilities, reducing the use of wooden pallets, and even turning the thermostat up in summer and down in winter are initiatives that improve processes and reduce costs, and also achieve sustainability goals. As part of the U.S. General Services Administration's smart building strategy, IBM is installing smart building technology in 50 of the federal government's highest-energy-consuming buildings, saving taxpayers \$15 million annually. By consolidating distribution centers, COSCO, China's largest shipping and logistics services supplier, reduced its overall fuel costs by 25%. Dow Chemical estimates that its sustainability initiatives have saved more than \$8 billion in fuel costs.

Along the Supply Chain

**Reducing Costs with Sustainability at UPS and FedEx**

UPS is the world's largest package delivery company delivering more than 16 million packages per day to more than 6 million customers in over 200 countries around the world. FedEx is the world's largest express transportation company with 4 million package deliveries daily to over 220 countries and territories with a fleet of 675 aircraft and 48,000 vehicles. Both companies are major providers of supply chain logistics, distribution, and transportation services, and are key partners in many companies' supply chains. Both have also been leaders in achieving sustainability that also cut their costs.



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FedEx Express has a holistic three-tiered vehicle sustainability strategy to improve the fuel efficiency of its fleet—"reduce,

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replace, and revolutionize.” In 2008 FedEx set a goal to improve fuel efficiency in its fleet of global vehicles by 20% by 2020, and when it surpassed this goal in 2012 it revised it to 30%. A “Fuel Sense” program based on the concept that “every drop counts” was developed and executed by a FedEx Express fleet team by making incremental changes to make fuel consumption in their aircraft fleet more efficient. Specific examples include pilots consciously waiting to start their last engine during taxi out, or shutting the first one down while taxiing in rather than at the gate; ramp agents loading more efficiently with an aft center of gravity (CG), which can reduce drag by 1.5%, representing an annual fuel savings potential of over \$7 million; technicians connecting ground power to aircraft quickly to reduce the usage of auxiliary aircraft power at ten times the cost; dispatchers reducing the amount of optional fuel planned on every flight, which saved \$1 million for every minute reduced across the fleet for a year; and ramp agents keeping the parking gates clear to allow taxiing aircraft to arrive and get into position quickly and efficiently, saving very expensive aircraft wait-time. Since 2007, when the program started, it has saved over 350 million gallons of jet fuel, enough energy to power 270,000 homes for a year, with a cost savings equal to four jet Boeing freighters, and it eliminates almost a half million metric tons of carbon emissions every year. FedEx is also putting old airplanes out of service, and replacing them with new more energy-efficient Boeing 767s, each one saving the company \$10 million per year in costs. The company is also adding new fuel-efficient ground vehicles to its fleet. The company works with a variety of manufacturers to advance vehicle technologies and make the best use of the conventional vehicles operated by the company. Simply matching the right vehicle to each route has made the biggest single impact on the fleet’s overall fuel efficiency.

Since 2001 UPS’s sustainability initiatives have saved almost 400 million miles of travel. It uses a number of technologies, analytics, and “big data” to achieve fuel efficiency across its ground fleet of 80,000 vehicles. Fuel efficiency starts even before the engines are turned on; UPS uses package-flow technologies that load vans effectively, minimizing the time it takes a driver to find the right package, thus quickening delivery. This translates into fewer miles traveled, which conserves fuel and reduces emissions. For years UPS route planners have designed routes to avoid left turns, reducing the amount of time spent idling waiting to turn left, which conserves fuel and reduces emissions, and is also a lot safer. In North America in the past decade UPS’s no-left-turns policy has saved 10 million gallons of gas and reduced CO<sub>2</sub> emissions by 100,000 metric tons. In general, the company maintains a strict anti-idle policy, which has cut the time trucks idle by 24 minutes per driver per day, resulting in a fuel savings of \$188 per driver per year. Routes are also designed to have the minimum number of stops and starts and still be on time. UPS tries to match the vehicle (i.e., powertrain) to the needs of the routes to get the best mileage, and it’s constantly looking for ways to make its vehicles more fuel efficient regardless of the powertrain. It worked with Isuzu and Utilimaster to develop lighter-weight composite-body diesel vans that achieved a 40% increase in fuel economy over traditional aluminum vans in testing. UPS also expects to save 40% in fuel costs by switching its long-haul semi-tractor trailer fleet to natural gas with prices 30% to 40% lower than diesel.

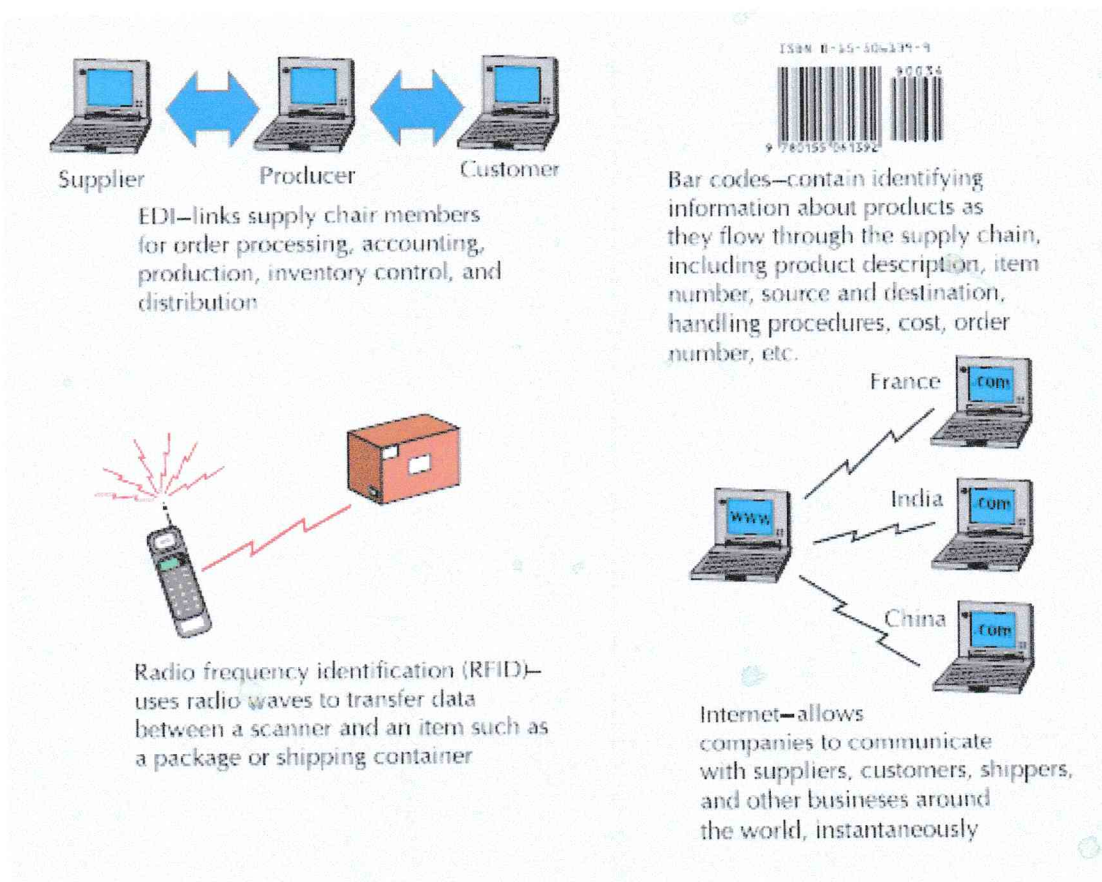
It employs a computer system called Orion (On Road Integrated Optimization and Navigation). The system employs telematics technology, which is geospatial mapping information combined with real-time communications with drivers to give them precise, optimized driving directions each morning and then update them during the day as customers request specific drop-off times, new drop-off destinations, and new pickups.

Sensors capture over 200 data points for more than 80,000 vehicles every day to help determine what packages are loaded on each truck; plan and track routes; provide insight into engine performance and condition; capture driver behavior and safety habits; report on emissions and fuel consumption; and monitor deliveries and customer service. By optimizing deliveries UPS estimates that in one year it saved over 206 million minutes of idling time, which saved more than 1.5 million gallons of fuel; it also reduced miles per delivery by over 12 million miles, avoiding 13,000 metric tons of CO2 emissions and saving 39 million gallons of gas.

## Information Technology: A Supply Chain Enabler

Information is the essential link between all supply chain processes and members. Computer and information technology allows real-time, online communications throughout the supply chain. Technologies that enable the efficient flow of products and services through the supply chain are referred to as “enablers,” and information technology has become the most important enabler of effective supply chain management.

Supply chain managers like to use the phrase “in modern supply chain management, information replaces inventory.” Although this statement is not literally true—companies need inventory at some point, not just information—information does change the way supply chains are managed, and these changes can lead to lower inventories. Without information technology, supply chain management would not be possible at the level it is currently being accomplished on a global basis. Some of the more important IT supply chain enablers are shown in **Figure 10.5**.



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## FIGURE 10.5 Supply Chain Enablers

### Electronic Business

**E-business** replaces physical processes with electronic ones. In e-business, supply chain transactions are conducted via a variety of electronic media, including electronic data interchange (EDI), email, electronic funds transfer (EFT), electronic publishing, image processing, electronic bulletin boards, shared databases, bar coding, fax, automated voice mail, CD-ROM catalogs, the Internet, websites, and so on. Companies are able to automate the process of moving information electronically between suppliers and customers. This saves both labor costs and time.

**E-business** The replacement of physical business processes with electronic ones.

Some of the features that e-business brings to supply chain management include:

- Cost savings and price reductions derived from lower transaction costs (including labor and document savings)
- Reduction or elimination of the role of intermediaries and even retailers and service providers, thus reducing costs
- Shortening supply chain response and transaction times for ordering and delivery
- Gaining a wider presence and increased visibility for companies
- Greater choices and more information for customers
- Improved service as a result of instant accessibility to services
- Collection and analysis of voluminous amounts of customer data and preferences
- The creation of virtual companies like [Amazon.com](http://Amazon.com) that distribute only through the Web, which can afford to sell at lower prices because they do not need to maintain retail space
- Leveling the playing field for small companies, which lack resources to invest in infrastructure (plant and facilities) and marketing
- Gaining global access to markets, suppliers, and distribution channels

### Electronic Data Interchange

**Electronic data interchange (EDI)** is a computer-to-computer exchange of business documents in a standard format, which has been established by the American National Standards Institute (ANSI) and the International Standards Organization (ISO). It creates a data exchange that allows trading partners to use Internet transactions instead of paper when performing purchasing, shipping, and other business. EDI links supply chain members together for order processing, accounting, production, and distribution. It provides quick access to information, allows better customer service, reduces paperwork, allows better communication, increases productivity, improves tracking and expediting, and improves billing and cost efficiency.

**Electronic data interchange (EDI)** A computer-to-computer exchange of business documents.

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EDI can be effective in reducing or eliminating the bullwhip effect discussed earlier in this chapter. With EDI, supply chain members are able to share demand information in real time, and thus are able to develop more accurate demand forecasts and reduce the uncertainty that tends to be magnified at each upstream stage of the supply chain.

## Bar Codes

A bar code is what is referred to as an “automated data collection” system, or “auto-ID.” In bar coding, computer-readable codes are attached to items flowing through the supply chain, including products, containers, packages, and even vehicles. The bar code contains identifying information about the item. It might include such things as a product description, item number, its source and destination, special handling procedures, cost, and order number. A food product can be identified down to the farmer who grew it and the field it was grown in. When the bar code information is scanned into a company’s computer by an electronic scanner, it provides supply chain members with critical information about the item’s location in the supply chain.

Bar code technology has had a huge influence on supply chain management, and it is used by thousands of companies in different situations. Package delivery companies like FedEx and UPS use bar codes to provide themselves and customers with instantaneous detailed tracking information. Supermarkets use scanners at cash registers to read prices, products, and manufacturers from Universal Product Codes (UPCs).

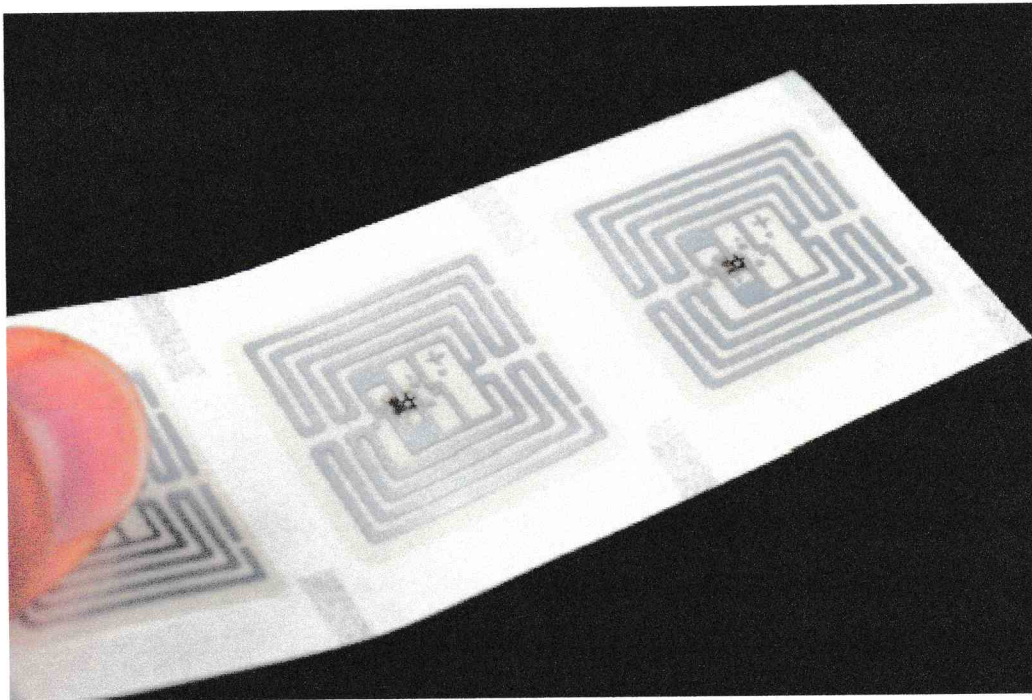
When bar codes are scanned at checkout counters, it also creates **point-of-sale data**—an instantaneous computer record of the sale of a product. This piece of information can be instantly transmitted throughout the supply chain to update inventory records. Point-of-sale data enable supply chain members—suppliers, producers, and distributors—to quickly identify trends, order parts and materials, schedule orders and production, and plan for deliveries.

**Point-of-sale data** Creates an instantaneous computer record of a sale.

## Radio Frequency Identification

While a barcode is the most commonly used auto-ID system, a more technologically advanced system is **radio frequency identification (RFID)**. RFID technology uses radio waves to transfer data between a reader (that is, a scanner) and an item such as a shipping container or a carton. RFID consists of a tiny microchip and computer, often a small, thin ribbon, which can be put in almost any form—for example between layers of cardboard in a box, or on a piece of tape or a label. An RFID “tag” stores a unique identification number. RFID scanners transmit a radio signal via an antenna to “access” the tag, which then responds with its number. The tag could be an Electronic Product Code (EPC), which could be linked to databases with detailed information about a product item.

**Radio frequency identification (RFID)** Can send product data from an item to a reader via radio waves.



With RFID technology, small individual electronic “tags” like these are attached to cartons, packages, or containers, which allows companies and organizations to track their every move around the world.

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Marc F. Henning/Alamy Stock Photo

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## The Internet

No technology has a bigger impact on supply chain management, and business in general, than the Internet. Through the Internet a business can communicate with customers and other businesses within its supply chain anywhere in the world in real time.

The Internet has eliminated geographic barriers, enabling companies to access markets and suppliers around the world that were previously inaccessible. By doing so, the Internet has shifted the advantage in the transaction process from the seller to the buyer, because the Internet makes it easier for companies to deal with many more suppliers around the world in order to get lower prices and better service.

The Internet adds speed and accessibility to the supply chain. Companies are able to reduce or eliminate traditional time-consuming activities associated with ordering and purchasing transactions by using the Internet to link directly to suppliers, factories, distributors, and customers. It enables companies to speed up ordering and delivery, track orders and delivery in real time, instantaneously update inventory information, and get instantaneous feedback from customers. This combination of accurate information and speed allows companies to reduce uncertainty and inventory. Internet commerce is expected to exceed \$6 trillion in this decade.

## Build-To-Order (BTO)

Dell was the first computer company to move to a direct-sell-to-customers model over the Internet. Its popular build-to-order (BTO) models were initially based on telephone orders by customers. Dell created an efficient supply chain using a huge number of weekly purchase orders faxed to suppliers. However, Dell now sends out orders to suppliers over the Internet every few hours or less. Dell's suppliers are able to access the company's inventories and production plans, and they receive constant feedback on how well they are meeting shipping schedules.

Dell's website allows the customer to configure a PC with the desired features; to order and track the order status, allowing the customer to follow their purchase in real time from order to delivery; and to be notified by email as soon as the order is shipped. Also, Dell created secure private sites for corporate and public sector customers to provide access to service and support information customized to the customer's products. In addition, Dell provides online access to technical reference materials and self-diagnostic tools that include symptom-specific troubleshooting modules that walk customers interactively through common systems problems.

## Supply Chain Integration

One of the keys to having a successful, efficient supply chain is to get the various supply chain members to collaborate and work together, that is, to get "in sync." This level of coordination is referred to as supply chain integration. Information technology is the key element in achieving supply chain integration through four areas—information sharing, collaborative planning, workflow coordination, and the adoption of new models and technologies. [Table 10.1](#) describes the positive effect each of these elements can have on supply chain performance.

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**TABLE 10.1 Supply Chain Integration**

*Information sharing among supply chain members*

- Reduced bullwhip effect
- Early problem detection
- Faster response
- Builds trust and confidence

*Collaborative planning, forecasting, replenishment, and design*

- Reduced bullwhip effect
- Lower costs (material, logistics, operating, etc.)
- Higher capacity utilization
- Improved customer service levels

*Coordinated workflow, production and operations, procurement*

- Production efficiencies
- Fast response
- Improved service
- Quicker to market

*Adopt new business models and technologies*

- Penetration of new markets
- Creation of new products
- Improved efficiency
- Mass customization

Information sharing includes any data that are useful to other members of the supply chain such as demand data, inventory stocks, and production and shipping schedules—anything that can help the supply chain members improve performance. Information needs to be transparent (i.e., not hidden) and easily accessible online. Collaborative planning defines what is done with the information that is shared. Workflow coordination defines how supply chain partners work together to coordinate their activities. Finally, adopting new business models and technologies is how supply chain members redesign and improve their supply chain performance.

**Collaborative planning, forecasting, and replenishment (CPFR)** is a process for two or more companies in a supply chain to synchronize their individual demand forecasts in order to develop a single plan for meeting customer demand. With CPFR, parties electronically exchange

a series of written comments and supporting data, which includes past sales trends, point-of-sale data, on-hand inventory, scheduled promotions, and forecasts. This allows participants to coordinate joint forecasts by concentrating on differences in forecast numbers. They review the data together, compare calculations, and collaborate on what is causing discrepancies. If there are no exceptions they can develop a purchase order and ship. CPFR does not require EDI; data can be sent via spreadsheets or over the Internet. CPFR is actual collaboration because both parties do the work and both parties share in fixing the problems. Sharing forecasts in this type of collaborative system can result in a significant decrease in inventory levels for both the manufacturer and distributor since it tends to reduce the “bullwhip effect” and thus lower costs. Many companies, including General Mills, Procter & Gamble, Hershey’s, and Cisco Systems participate in some form of CPFR with their suppliers.

**Collaborative planning, forecasting, and replenishment(CPFR)** A process for two or more companies in a supply chain to synchronize their demand forecasts into a single plan to meet customer demand.

## Supply Chain Management (SCM) Software

**Enterprise resource planning (ERP)** is software that helps integrate the components of a company, including most of the supply chain processes, by sharing and organizing information and data among supply chain members. It transforms transactional data like sales into useful information that supports business decisions in other parts of the company. For example, when data such as a sale becomes available in one part of the business, it is transmitted through ERP software, which automatically determines the effects of the transaction on other areas, such as manufacturing, inventory, procurement, invoicing, distribution, and accounting, and on suppliers. Through these information flows ERP organizes and manages a company’s supply chain. Most ERP vendors systems handle external, Web-based interactions, and have software specifically for supply chain management called “SCM.”

**Enterprise resource planning (ERP)** Software that integrates the components of a company by sharing and organizing information and data.

SAP was the first ERP software provider and is the largest, which has made it almost synonymous with ERP applications software. [mySAP.com](http://mySAP.com) is the umbrella brand name for the SAP software. [mySAP.com](http://mySAP.com) is a suite of Web-enabled SAP modules that allow a company to collaborate with its customers and business partners along its supply chain. When a customer submits an order, that transaction ripples throughout the company’s supply chain, adjusting inventory, part supplies, accounting entries, production schedules and shipping schedules, and balance sheets. Different nations’ laws, currencies, and business practices are embedded in the software, which enables it to translate sales transactions smoothly between business partners in different countries—for example, a company in Taiwan and its customer in Brazil.

ERP is discussed in greater detail in Chapter 15, “Resource Planning.”

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## Measuring Supply Chain Performance

As we indicated in previous sections, inventory is a key element in supply chain management. On one hand, it enables a company to cope with uncertainty by serving as a buffer between stages in the supply chain. Inventory allows items to flow smoothly through the system to meet customer demand when stages are not in sync. On the other hand, inventory can be very costly. Thus, it is important for a company to maintain an efficient supply chain by lowering inventory levels (and costs) as much as possible. In order to accomplish this objective, several numerical measures, also called **key performance indicators (KPIs)** or metrics, are often used to measure supply chain performance. Three of the more widely used key performance indicators are inventory turnover, inventory days of supply, and fill rate.

**Key performance indicators (KPIs)** Metrics used to measure supply chain performance.

## Key Performance Indicators

**Inventory turnover (or turns)** is computed by dividing the cost of goods sold (i.e., the cost of annual sales) by the average aggregate inventory value:

**Inventory turns** A supply chain performance metric computed by dividing the cost of goods sold by the average aggregate value of inventory.

$$\text{Inventory turns} = \frac{\text{Cost of goods sold}}{\text{Average aggregate value of inventory}}$$

The average aggregate value of inventory is the total value (at cost) of all items being held in inventory, including such things as raw materials, work-in-process (WIP), and finished goods. It is computed by summing, for all individual inventory items, the product of the average number of units on hand in inventory at any one time multiplied by the unit value:

$$\text{Average aggregate value of inventory} = \sum (\text{average inventory for item } i) \times (\text{unit value item } i)$$

The cost of goods sold is only for finished goods, valued at cost, not the final sale price (which might include discounts or markups).

Every time product items are sold that are equal to the average amount of money that was invested in those items, then the inventory has been turned. An item whose inventory is sold (i.e., turns over) once a year has higher holding costs (for rent, utilities, insurance, theft, etc.) than one that turns over twice, three times, or more in that same time period. For example, if a firm that sells products that cost \$10,000 in a year has a total revenue from the sale of these products of \$15,000, the gross profit is \$5,000. However, suppose instead the company only purchased \$5,000 worth of product at the first of the year, and then just before running out of stock, it bought an additional \$5,000 of product with part of the revenues from selling the first batch. The company still invested \$10,000 in products and made revenues of \$15,000, but only

on an investment of \$5000. Which strategy is better—making \$5000 gross profit on an investment of \$10,000 or \$5000? It is better to invest the smaller amount; with a \$5000 investment the company has freed up \$5000 for part of the year to invest in other things it could make a profit on, and it has reduced its holding costs. However, the trick is to invest the minimum amount possible in products and reorder at just the right time to avoid stockouts. This is why a company with good supply chain management has more inventory turns than a company that does not.

A poor, or comparatively low, inventory turnover indicates that a large amount of inventory is required to satisfy demand. In general, a good (or poor) number of inventory turns is relative to what is being achieved at various stages across a company and what the industry norm is. Only comparisons of inventory turns for companies within the same industry are meaningful. Comparing a supermarket to a car dealer is not meaningful; a supermarket sells fast-moving products so its inventory turns will be higher than a car dealer that sells slow-moving items. In the 1980s, inventory turns for many manufacturing companies were less than five; however, the advent of lean production (see Chapter 16) and the increased focus on quality management and supply chain management have increased inventory turns in much of the manufacturing sector to about six turns per year for a typical company. Although this seems like a small change, it still represents a significant decrease in costs and increase in profits. On the other hand, a typical computer company or grocery store will have 12 turns or more per year.

Toyota had inventory turns in the 60s in the 1980s when its supply chain was mostly in Japan, but this has fallen to between 10 and 12 in recent years as it has expanded globally and the complexities of its supply chain have increased accordingly. High-tech companies typically have around six turns per year, but Dell has achieved inventory turns greater than 50, attesting to its supply chain success. On the other hand, pharmaceutical giant Pfizer has had recent inventory turns as low as 1.5. However, this does not mean that Pfizer is doing poorly financially—it has been very profitable. It does mean that perhaps it could manage its supply chain more efficiently.

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## Along the Supply Chain

### Amazon Leader Among Top-Ten Supply Chains

In Gartner Inc.'s annual "Supply Chain Top 25" report in 2015, Amazon was ranked first followed in the top ten by retail and manufacturing giants McDonald's, Unilever, Intel, Inditex, Cisco Systems, H&M, Samsung, Colgate-Palmolive, and Nike. Perennial first place supply chain company, Apple, and top-five company, Proctor & Gamble, were placed in a new category, "Supply Chain Masters," recognizing companies that have consistently been among the top five supply chains for at least seven out of the past ten years. The report identifies the manufacturers and retailers that exhibit superior supply chain capabilities and performance based on a score derived from supply chain financial metrics—three-year weighted return on assets, three-year weighted revenue growth, and inventory turns—plus a survey of supply chain professionals, and Gartner's analysts' opinions. Among the top 25 companies, Amazon's overall score was only about 2% higher than second-ranked McDonald's. For the three metrics Gartner uses to develop its scores, Amazon had zero weighted average return on assets due to large investments in future products and services; the eighth highest inventory turns (8.7 compared to second-ranked McDonald's 157.3); and the highest revenue growth (21.7% compared to Qualcomm, ranked nineteenth at 17.8%), which is the highest weighted score metric. Amazon's 8.7 inventory compared to McDonald's 157.3 is impressive given that McDonald's sells a huge number of food items on a daily basis, while Amazon sells a massive variety of consumer products.

In its ranking report Gartner cited three recent trends among the top-ranked companies—bimodal supply chain strategies, increased customer intimacy, and emerging digital business models. It defines a bimodal strategy as one where companies will devote as much time to growing and innovating as they will streamlining and promotion efficiency, which promotes flexibility and growth. It sees companies focusing on the customer experience within the supply chain as a top priority, as well as companies leveraging digital capabilities to support new business models. In addition, most of the top-25 companies are product and supply chain innovators who have successfully introduced new products and features and that have successfully been able to improve the resiliency of their global supply chains to mitigate the risk of supply and demand disruptions, such as natural disasters and catastrophes. Supply chain leaders also streamline their supply chains by simplifying their products lines and eliminating less profitable products. These leaders also eliminate infrequently used product features, service offerings, distribution network capacity, and supply chain layers that do not add sufficient value to customers. All of the top supply chain companies have forward-thinking, cost-saving programs for environmental, social, and labor sustainability throughout their global supply chains.



Bloomberg/Getty Images, Inc.

Identify some of the other companies on Gartner Inc.'s Top 25 list and describe their similarities with other companies on the list.

Sources: Based on Stan Aronow, Michael Burkett, Kimberly Nilles, and Jim Romano, "The Gartner Supply Chain Top 25 for 2015," [www.gartner.com](http://www.gartner.com), (May 13, 2015).

Another commonly used KPI is days (or weeks) of supply. This is a measure of how many days (or weeks) of inventory is available at any point in time. It is computed by dividing the aggregate average value of inventory by the daily (or weekly) cost of goods sold,

$$\text{Days of supply} = \frac{\text{Average aggregate value of inventory}}{(\text{Cost of goods sold}) / (365 \text{ days})}$$

Automotive companies typically carry about 60 days of finished goods supply.

Another frequently used KPI is **fill rate**. Fill rates are the fraction of orders placed by a customer with a supplier distribution center or warehouse that are filled within a specific period of time, typically one day. High fill rates indicate that inventory is moving from the supplier to the customer at a faster rate, which thereby reduces inventory at the distribution center. For example, Nabisco's fill rate for its Planter's peanuts at Wegman's grocery store chain is 97%, meaning that when the store places an order with the Nabisco distribution center, 97% of the time it is filled within one day.

**Fill rate** The fraction of orders filled by a distribution center within a specific time period.

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### EXAMPLE 10.1 | Computing Key Performance Indicators

The Tomahawk Motorcycle Company manufactures motorcycles. Last year the cost of goods sold was \$425 million. The company had the following average value of production materials and parts, work-in-process, and finished goods inventory:

Production materials and parts	\$ 4,629,000
Work-in-process	17,465,000
Finished goods	12,322,000
Total average aggregate value of inventory	\$34,416,000

The company wants to know the number of inventory turns and days of supply being held in inventory.

#### Solution:

$$\begin{aligned}
 \text{Inventory turns} &= \frac{\text{Cost of goods sold}}{\text{Average aggregate value of inventory}} \\
 &= \frac{\$425,000,000}{34,416,000} \\
 \text{Inventory turns} &= 12.3 \\
 \text{Days of supply} &= \frac{\text{Average aggregate value of inventory}}{(\text{Cost of goods sold})/(365 \text{ days})} \\
 &= \frac{\$34,416,000}{(425,000,000)/(365)} \\
 \text{Days of supply} &= 29.6
 \end{aligned}$$

## Process Control

In Chapter 2, “Quality Management,” we talked about various techniques that could be employed to monitor product and service quality. One of the more powerful techniques we presented was statistical process control, the subject of Chapter 3. Although we tend to think that process control is used to monitor and control quality for manufacturing operations, it can also be used to monitor and control any of the processes in the supply chain. If products are defective, then the effects are obvious. However, other problems along the supply chain that create uncertainty and variability are most often caused by errors. If deliveries are missed or are late, if orders are lost, if errors are made in filling out forms, if items with high obsolescence rates (like PCs) or perishable items are allowed to stay too long in inventory, if demand forecast errors are made, if plant and equipment are not properly maintained, then the supply chain can

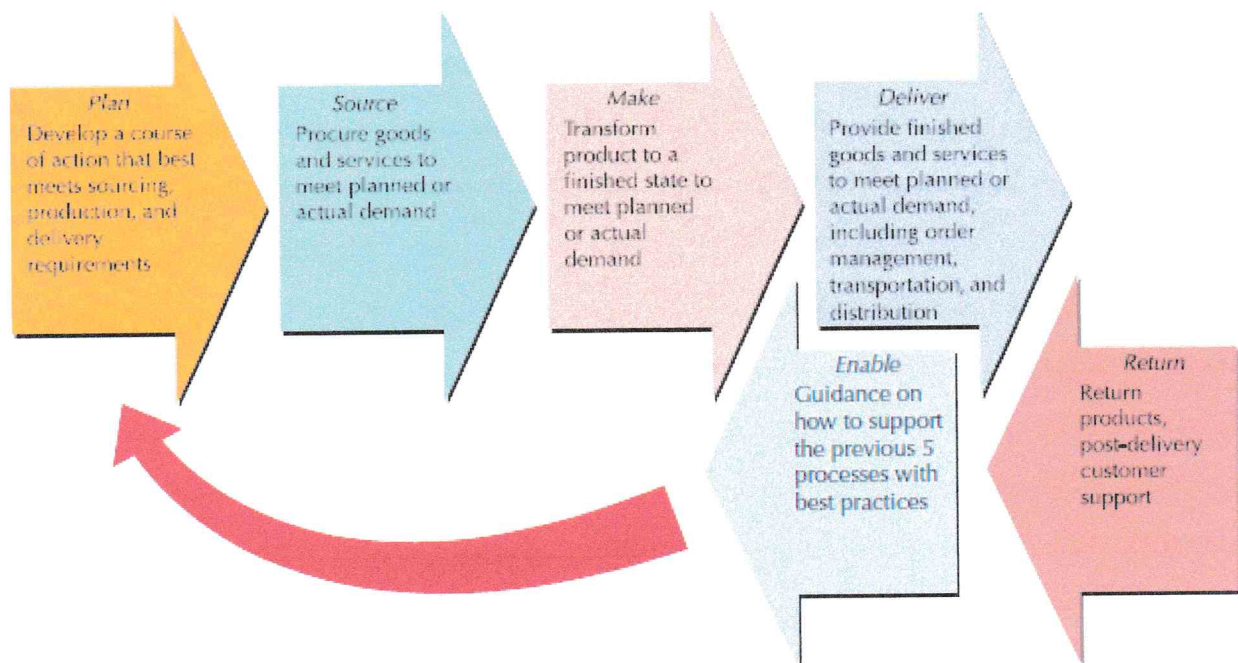
be disrupted, thereby reducing supply chain performance. Thus, at any stage in the process, statistical process control charts can be used to monitor process performance.

## SCOR

The **supply chain operations reference (SCOR)** model is a supply chain diagnostic tool that provides a cross-industry standard for supply chain management. It was developed by the Supply Chain Council, a global not-for-profit trade association organized in 1996 with membership open to companies interested in improving supply chain efficiency primarily through the use of SCOR. The Supply Chain Council (SCC) has almost 1,000 corporate members around the world, including many Fortune 500 companies. In 2014 the SCC merged with the American Production and Inventory Control Society (APICS), with 43,000 members, which maintains the SCOR model.

**Supply chain operations reference(SCOR)** A cross-industry supply chain diagnostic tool maintained by the Supply Chain Council.

The purpose of the SCOR model is to define a company's current supply chain processes, quantify the performance of similar companies to establish targets to achieve "best-in-class" performance, and identify the practices and software solutions that will yield "best in class" performance. It is organized around a set of six primary management processes—plan, source, make, deliver, return, and return, as shown in **Figure 10.7**. These processes provide a common set of definitions, or building blocks, that SCOR uses to describe any supply chain, from simple to complex. This allows supply chains for different companies to be linked and compared. The closed loop nature of these processes is similar to the Deming Wheel (PDCA cycle) and the Six Sigma DMAIC steps (chapter 2).



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### FIGURE 10.7 SCOR Level Processes

A primary feature of the SCOR model is a set of five performance attributes of a supply chain—reliability, responsiveness, agility, costs, and asset management—that enable it to be analyzed and evaluated against other competing supply chains. Reliability, responsiveness, and agility are more customer-focused attributes while cost and asset management are more internally focused. Associated with each performance attribute are various quantitative metrics that an organization can calculate to determine how well its supply chain is performing within its industry. There are over 250 SCOR metrics organized within a three tiered hierarchy according to level 1 (strategic), level 2 (processes), and level 3 (diagnostic). [Table 10.2](#) summarizes and defines the SCOR performance attributes and shows the level 1 metrics for each attribute with their description.

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**TABLE 10.2 SCOR Performance Attributes and Metrics**

PERFORMANCE ATTRIBUTE	DEFINITION	STRATEGIC METRICS	DEFINITION
Reliability	The ability to perform as expected, focusing on predictability of processes; on time, right amount, quality	Perfect order fulfillment	Percentage of orders delivered on time and in full, with no errors
Responsiveness	The speed at which the supply chain provides products to the customer	Order fulfillment cycle time	Time from order receipt to customer delivery, sourcing time, make time, delivery time, retail delivery time
Agility	Responsiveness to external influences and marketplace changes	Upside supply chain adaptability	Days required for the supply chain to respond to an unplanned 20% increase in demand without a cost penalty
		Upside supply chain adaptability	The quantity of increased production that can be achieved and sustained in 30 days
		Downside supply chain adaptability	The reduction in quantities ordered 30 days prior to delivery with no cost penalties
		Overall value at risk (VAR)	measures the impact of supply chain disruptions; the sum of the probability of risk events multiplied by the financial impact of the events for all supply chain processes
Cost	The cost of operating the supply chain including labor, material, transportation, and management	Total cost to serve	The direct and indirect costs to plan source, make and deliver product and services, including material and labor
Asset management efficiency	Efficiently utilizing assets including inventory reduction and in-sourcing vs. outsourcing	Cash-to-cash cycle time	Inventory days of supply (WIP)

		Return on fixed assets	Fixed supply chain asset value, supply chain revenue
		Return on working capital	Accounts payable, receivable, and inventory

These metrics can be used to develop a “SCOR mark” that benchmarks a company’s current supply chain performance for different processes against its industry competitors’ metrics. The company then projects the level of metrics it needs to be on a par with its competitors, to have an advantage over its competitors, or to be superior. The value associated with these measured improvements in performance is then projected for the different performance attributes. For example, a company may know that the industry “median fill rate (the percentage of orders shipped from stock within 24 hours of order receipt)” is 90% and the industry best-in-class performance is 99%. The company has determined that its current fill rate is 65%, and that a fill rate of 90% will give it parity with its competitors, a 95% fill rate will give it an advantage, and a 99% fill rate will make it superior to most of its competitors. The company may then project that the improvement in its fill rate plus improvements in the other supply chain reliability attributes (i.e., delivery performance and perfect order fulfillment) will increase supply chain value by \$10 million in revenue. SCOR provides a framework not only for measuring performance but for diagnosing problems and identifying practices and solutions that will enable a company to achieve its competitive performance objectives.

SCOR also has a special application called GreenSCOR designed to address environmental sustainability efforts. The SCOR framework provides a structure for measuring environmental performance and where it can be improved using the following strategic metrics: carbon emissions, air pollutant emissions, liquid waste, solid waste, and percent recycled waste.

## Summary

Supply chain management is one of the most important strategic aspects of operations management because it encompasses so many related functions. Who to buy materials from, how to transport goods and services, and how to distribute them in the most cost-effective, timely manner constitutes much of an organization’s strategic planning. Contracting with the wrong supplier can result in poor-quality materials and late deliveries. Selecting the wrong mode of transportation or carrier can mean late deliveries to customers that will require high, costly inventories to offset. All of these critical functional supply chain decisions are complicated by the fact that they often occur in a global environment within cultures and markets at a distance and much different from those in the United States.

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## Key Terms

**bullwhip effect** Occurs when demand variability is magnified at various upstream points in the supply chain.

**collaborative planning, forecasting, and replenishment (CPFR)** A process for two or more companies in a supply chain to synchronize their demand forecasts into a single plan to meet customer demand.

**e-business** The replacement of physical business processes with electronic ones.

**electronic data interchange (EDI)** A computer-to-computer exchange of business documents.

**enterprise resource planning (ERP)** Software that connects the components of a company by sharing and organizing information and data.

**fill rate** The fraction of orders placed by a customer with a supplier distribution center or warehouse that are filled within 24 hours.

**inventory** Insurance against supply chain uncertainty held between supply chain stages.

**inventory turns** A supply chain performance metric computed by dividing the cost of goods sold by the average aggregate value of inventory.

**key performance indicator (KPI)** A metric used to measure supply chain performance.

**point-of-sale data** Computer records of sales at retail sites.

**procurement** Purchasing goods and services from suppliers.

**radio frequency identification (RFID)** Radio waves used to transfer data, like an electronic product code, between an item with an embedded microchip and a reader.

**risk pooling** An approach to risk management that aggregates risk to reduce its impact.

**SCOR** The supply chain operations reference model; a diagnostic tool that provides a cross-industry standard for supply chain management.

**supply chain** The facilities, functions, and activities involved in producing and delivering a product or service from suppliers (and their suppliers) to customers (and their customers).

**supply chain management (SCM)** Managing the flow of information through the supply chain in order to attain the level of synchronization that will make it more responsive to customer needs while lowering costs.

**sustainability** Meeting present needs without compromising the ability of future generations to meet their needs.

**value** The creation of value for the customer is an important aspect of supply chain management.

**value chain** A more contemporary name for a supply chain.

# Key Formulas

$$\text{Inventory turns} = \frac{\text{Cost of goods sold}}{\text{Average aggregate value of inventory}}$$

$$\text{Days of supply} = \frac{\text{Average aggregate value of inventory}}{(\text{Cost of goods sold}) / (365 \text{ days})}$$

## Solved Problems

WileyPLUS

### Inventory Turns and Days of Supply

A manufacturing company had the following average raw materials, work-in-process, and finished goods inventory on hand at any one time during the past year.

RAW MATERIALS	AVERAGE INVENTORY	UNIT COST
1	135	\$26.50
2	67	18.20
3	210	9.75
4	97	31.25
WORK-IN-PROCCSS		
5	40	\$165.00
6	65	230.00
FINISHED GOODS	AVERAGE INVENTORY	UNIT COST
7	25	\$ 670.00
8	18	1050.00
9	35	520.00

The company's cost of goods sold last year was \$2.73 million, and it operates 365 days per year. Determine the company's inventory turns and days of supply.

**Solution**

**Step 1.** Compute the average aggregate value of inventory.

Raw materials : (135)(\$26.50)	=	\$3,577.50
(67)(18.20)	=	1,219.40
(210)(9.75)	=	2,047.50
(97)(31.25)	=	3,031.25
Work-in-process : (40)(165)	=	6,600.00
(65)(230)	=	14,950.00
Finished goods : (25)(670)	=	16,750.00
(18)(1050)	=	18,900.00
(35)(520)	=	<u>18,200.00</u>
Total		\$85,275.65