

# Sourcing Decisions in a Supply Chain

## LEARNING OBJECTIVES

After reading this chapter, you will be able to

1. Understand the role of sourcing in a supply chain.
2. Discuss factors that affect the decision to outsource a supply chain function.
3. Identify dimensions of supplier performance that affect total cost.
4. Describe the benefits of sharing risk and reward.
5. Design a tailored supplier portfolio.

In this chapter, we explore various factors that influence decisions about whether a supply chain activity is performed within the firm or outsourced. We also discuss performance characteristics of suppliers that affect total cost. Our goal is to enable managers to consider all the trade-offs involved when making sourcing decisions to maximize value extracted from every stage of a sourcing relationship.

## 15.1 THE ROLE OF SOURCING IN A SUPPLY CHAIN

*Purchasing*, also called *procurement*, is the process by which companies acquire raw materials, components, products, services, or other resources from suppliers to execute their operations. *Sourcing* is the entire set of business processes required to purchase goods and services. For any supply chain function, the most significant decision is whether to outsource the function or perform it in-house. *Outsourcing* results in the supply chain function being performed by a third party. Outsourcing decisions are important and tend to vary across firms and industries. For example, W.W. Grainger, an MRO distributor, has consistently owned and managed its distribution centers. In contrast, outbound transportation of packages from distribution centers to customers has consistently been outsourced to a third party. What factors can explain Grainger's decisions?

Until 2005, Dell was credited with improving profits by keeping the retail function in-house and selling directly to customers. Since 2007, however, Dell has started to outsource retailing to firms such as Walmart. Dell has also increased the fraction of assembly that it outsources to contract manufacturers. Why was vertical integration into retailing a good idea for Dell until about 2005 but not after 2007? Was Dell right in outsourcing a greater fraction of assembly to contract manufacturers? In contrast to Dell, Apple has significantly expanded the insourcing of retailing during the same period by growing Apple retail stores. Procter & Gamble (P&G) has never attempted to sell detergent directly to customers, and no one is calling on it to bring the retail function in-house. What made vertical integration into retailing a good idea for Apple but a bad idea for P&G? Most companies outsource assembly in consumer electronics. In contrast, most companies insource assembly in the automotive industry. What factors may explain this difference?

We address the outsourcing of supply chain activities by a firm based on the following three questions:

1. Will the third party increase the supply chain surplus relative to performing the activity in-house?
2. To what extent do risks grow upon outsourcing?
3. Are there strategic reasons to outsource?

Recall that the supply chain surplus is the difference between the value of a product for the customer and the total cost of all supply chain activities involved in bringing the product to the customer. Our basic premise is that outsourcing makes sense if it increases the supply chain surplus (assuming we get to keep some of the increase) without significantly increasing risks. A sourcing decision should aim to increase the net value created by the supply chain.

For example, P&G has historically outsourced retailing of its products to others. The third parties increase the supply chain surplus by aggregating many products that customers need (not just P&G products) in a single retail store. This aggregation allows them to spread facility costs, selling costs, personnel costs, and transportation costs across many consumer goods manufacturers. This aggregation also allows the retailer to increase customer value by allowing them to purchase many products they need in a single visit to the store. Clearly, outsourcing retailing to a third party increases the value created by the supply chain to a greater extent than if P&G managed its own retailing. Good sourcing decisions grow value by assigning each activity within the supply chain to the party that can add the most value.

Effective sourcing processes within a firm can improve profits for the firm, as well as total supply chain surplus, in a variety of ways. It is important that the drivers of improved profits be clearly identified when making sourcing decisions. The following are some of the benefits from effective sourcing decisions:

- Identifying the right source can result in an activity performed at higher quality and lower cost.
- Better economies of scale can be achieved if orders within a firm are aggregated.
- More efficient procurement transactions can significantly reduce the overall cost of purchasing. This is most important for items for which a large number of low-value transactions occur.
- Design collaboration can result in products that are easier to manufacture and distribute, resulting in lower overall costs. This factor is most important for components that contribute a significant amount to product cost and value.
- Good procurement processes can facilitate coordination with the supplier and improve forecasting and planning. Better coordination lowers inventories and improves the matching of supply and demand.
- Appropriate sharing of risk and benefits can result in higher profits for both the supplier and the buyer.
- Firms can achieve a lower purchase price by increasing competition through the use of auctions.

When designing a sourcing strategy, it is important for a firm to be clear on the factors that have the greatest influence on performance and target improvement on those areas. For example, if most of the spending for a firm is on materials with only a few high-value transactions, improving the efficiency of procurement transactions will provide little value, whereas improving design collaboration and coordination with the supplier will provide significant value. In contrast, when sourcing items with many low-value transactions, increasing the efficiency of procurement transactions will be valuable.

In the next section, we discuss factors that influence the outsourcing decision.

## 15.2 IN-HOUSE OR OUTSOURCE?

The decision to outsource is based on the growth in supply chain surplus provided by the third party and the increase in risk incurred by using a third party. A firm should consider outsourcing if the growth in surplus is large with a small increase in risk. Performing the function in-house is preferable if the growth in surplus is small or the increase in risk is large.

### How Do Third Parties Increase the Supply Chain Surplus?

Third parties increase the supply chain surplus if they either increase value for the customer or decrease the supply chain cost relative to a firm performing the task in-house. Third parties can increase the supply chain surplus effectively if they are able to aggregate supply chain assets or flows to a higher level than a firm itself can. Here, we discuss various mechanisms that third parties can use to grow the surplus.

**1. Capacity aggregation.** A third party can increase the supply chain surplus by aggregating demand across multiple firms and gaining production economies of scale that no single firm can on its own. This is the most common reason for outsourcing production in a supply chain. One of the reasons that all smartphone manufacturers outsource glass manufacturing for their screens is that the third parties achieve manufacturing economies that no single smartphone manufacturer can on its own. The growth in surplus from outsourcing is highest when the needs of the firm are significantly lower than the volumes required to gain economies of scale. A good example in this context is Magna Steyr, a third party that has taken over assembly of automobiles for several manufacturers. Magna Steyr designs flexible assembly lines that can build up to five different vehicle types on a single line. This flexible capacity allows the company to produce a variety of low volume cars economically. In 2013, Magna Steyr assembled the G class for Mercedes, the RCZ for Peugeot, and the Mini Countryman and Mini Paceman for BMW in the same plant. In each case, the models had relatively low demand volume. Each firm would not have gained sufficient economies of scale for assembling its model. By combining all of them in a single flexible plant, Magna Steyr grew the surplus relative to each firm assembling its own cars. A third party is unlikely to increase the surplus through capacity aggregation if the volume requirements of a firm are large and stable. This is substantiated by the fact that no auto manufacturer outsources production of its best-selling cars to a third party.

**2. Inventory aggregation.** A third party can increase the supply chain surplus by aggregating inventories across a large number of customers. W.W. Grainger and McMaster-Carr are MRO suppliers that provide value primarily by aggregating inventory for hundreds of thousands of customers. Aggregation allows them to significantly lower overall uncertainty and improve economies of scale in purchasing and transportation. As a result, these MRO distributors carry significantly less safety and cycle inventory than would be required if each customer decided to carry inventory of MRO products on its own. Another example of inventory aggregation is provided by Brightstar, a distributor that facilitates postponement for cell phones. These phones are manufactured in the Far East and shipped to the Brightstar warehouse in Miami, where software and accessories are added as customer orders arrive from South America. High product variety

and many small customers allow Brightstar to increase the supply chain surplus through inventory aggregation and postponement. The third party performing inventory aggregation adds most to the supply chain surplus when demand from customers is fragmented and uncertain. When demand is large and predictable, an intermediary adds little to the surplus by holding inventory. The consolidation of retailing and the resulting scale and predictability of demand for large retailers explain why distributors play a much smaller role in the United States than in developing countries.

**3. Transportation aggregation by transportation intermediaries.** A third party may increase the surplus by aggregating the transportation function to a higher level than any shipper can on its own. UPS, FedEx, and a host of LTL carriers are examples of transportation intermediaries that increase the supply chain surplus by aggregating transportation across a variety of shippers. The value provided in each case is driven by the inherent economies of scale in transportation. When shippers want to send small quantities, the transportation intermediary aggregates shipments across multiple shippers, thus lowering the cost of each shipment below what could be achieved by the shipper alone. A transportation intermediary increases the supply chain surplus when shippers are sending packages or LTL quantities to customers that are geographically distributed. A transportation intermediary can also grow the surplus for TL shipping by aggregating across multiple firms having unbalanced transportation flows, with the quantity coming into a region being very different from the quantity leaving the region. An excellent example of a transportation intermediary increasing the supply chain surplus is provided by a pilot program involving Chrysler and Ford. Exel, a third-party logistics (3PL) provider, operated a dedicated fleet for the distribution of spare parts for Chrysler. In tests in Michigan and Mexico, Ford added its own truck parts for delivery on the same fleet. Given the relatively low density of dealers in Northern Michigan and Mexico (outside Mexico City), the aggregation provided by Exel was a benefit for both Ford and Chrysler. A transportation intermediary is likely to add the least to the supply chain surplus for a company such as Walmart, for which shipment sizes are large and the company achieves aggregation across the many retail stores that it owns. The only possibility for a transportation intermediary in such a setting would be to obtain better backhauls than Walmart does.

**4. Transportation aggregation by storage intermediaries.** A third party that stores inventory can also increase the supply chain surplus by aggregating inbound and outbound transportation. Storage intermediaries such as W.W. Grainger and McMaster-Carr stock products from more than a thousand manufacturers each and sell to hundreds of thousands of customers. On the inbound side, they are able to aggregate shipments from several manufacturers onto a single truck. This results in a lower transportation cost than could be achieved by each manufacturer independently. On the outbound side, they aggregate packages for customers at a common destination, resulting in a significantly lower transportation cost than can be achieved if each supplier shipped to each customer separately. For example, the Chicago distribution center for Grainger fills separate trucks with packages destined for each adjacent state. As soon as a truck destined for Michigan (for instance) is filled, it is sent to the UPS sorting facility in Michigan. This level of aggregation cannot be achieved by individual suppliers or customers. Thus, the storage of goods by Grainger and McMaster-Carr increases the supply chain surplus by aggregating inbound and outbound transportation. A similar service is provided by distributors in countries such as India. Given the small size of retail outlets, a distributor aggregates delivery for several manufacturers, significantly lowering the outbound transportation cost. This form of aggregation is most effective if the intermediary stocks products from many suppliers and serves many customers, each ordering in small quantities. This form of aggregation becomes less effective as the scale of shipment from a supplier to customer grows. This is seen in the decreased use of distributors by U.S. supermarket chains. The supermarkets typically get full trucks delivered to their DCs or stores and do not need distributors for further aggregation.

**5. Warehousing aggregation.** A third party may increase the supply chain surplus by aggregating warehousing needs over several firms. The growth in surplus is achieved in terms of lower real estate costs and lower processing costs within the warehouse. Savings through warehousing aggregation arise if a firm's warehousing needs are small or if its needs fluctuate over time. In either case, the intermediary with the warehouse can exploit economies of scale in warehouse construction and operation by aggregating across multiple customers. An example is Safexpress, a third-party logistics provider in India. Safexpress owns warehouses distributed throughout the country that are used by many of its customers. Most of its customers do not have warehousing needs that are large enough to justify a warehouse of their own in each region. Warehousing aggregation by an intermediary adds a lot to the surplus for small suppliers and for companies that are starting out in a geographic location. Warehousing aggregation is unlikely to add much to the surplus for a large supplier or customer whose warehousing needs are large and relatively stable over time. The warehousing needs of Walmart, Amazon, and Grainger are sufficiently large and stable to justify their own warehouses, and a third party is unlikely to increase the surplus.

**6. Procurement aggregation.** A third party increases the supply chain surplus if it aggregates procurement for many small players and facilitates economies of scale in ordering, production, and inbound transportation. Procurement aggregation is most effective across many small buyers. Small retailers in India purchase goods from distributors that aggregate buying from manufacturers. Procurement aggregation is not likely to be a big factor with a few large customers. For example, Walmart has sufficient scale that it manages its own procurement. It sees no value added in procuring through a third party.

**7. Information aggregation.** A third party may increase the surplus by aggregating information to a higher level than can be achieved by a firm performing the function in-house. All retailers aggregate information on products from many manufacturers in a single location. This information aggregation reduces search costs for customers. eBags is an example of an online retailer that primarily provides information aggregation. eBags holds little inventory but is a single point of display for information on bags from many manufacturers. By aggregating product information, eBags significantly reduces search costs for the online customer. Relative to eBags, if each manufacturer set up its own website and online store, search costs for the customer would be higher, and each manufacturer would have to invest in the information infrastructure. Thus, eBags increases the supply chain surplus through information aggregation by making search cheaper and reducing investment in information technology. Two other examples of companies using information aggregation are W.W. Grainger and McMaster-Carr. Both provide product catalogs and detailed websites. This simplifies search by the customer and aggregates product information for more than a thousand manufacturers. Another excellent example of information aggregation is provided by the various online sites, such as Freight Zone and Echo Global Logistics, that bring together shippers and truckers looking for shipments. Information aggregation reduces search costs and allows better matching of truckers and shipments. Information aggregation increases the surplus if both buyers and sellers are fragmented and buying is sporadic. Information aggregation is not likely to be a big factor for a car manufacturer that regularly buys steel from a single supplier.

**8. Receivables aggregation.** A third party may increase the supply chain surplus if it can aggregate the receivables risk to a higher level than the firm or it has a lower collection cost than the firm. Brightstar, for example, was a distributor for Motorola in most Latin American countries other than Brazil. Cell phones in the area are sold through many small, independently owned retail outlets. Collecting receivables from each retail outlet is an expensive proposition for a manufacturer. Given that a retailer buys from many manufacturers, the power of each manufacturer to collect is also reduced. Brightstar, as a distributor, was able to aggregate collection across all manufacturers that it served, reducing the collection cost. By aggregating collection to a greater extent than any one manufacturer can, Brightstar also lowered the default risk. Reduced collection

cost and risk allowed Brightstar to increase the supply chain surplus relative to having this activity performed by manufacturers. The same is true with distributors in India that often distribute for a large number of manufacturers to the same retailer. Given their ability to aggregate across many manufacturers and small retailers, distributors in India typically take responsibility for managing receivables from the retailers. Receivables aggregation is likely to increase the supply chain surplus if retail outlets are small and numerous and each outlet stocks products from many manufacturers that are all served by the same distributor. Such a scenario is more likely in developing countries where retailing is fragmented. It is less likely in developed countries, such as the United States and most Western European countries, where retailing is consolidated.

**9. Relationship aggregation.** An intermediary can increase the supply chain surplus by decreasing the number of relationships required between multiple buyers and sellers. Without an intermediary, connecting a thousand sellers to a million buyers requires a billion relationships. The presence of an intermediary lowers the number of relationships required to just over a million. Most retailers and MRO distributors such as W.W. Grainger improve supply chain surplus through relationship aggregation. Relationship aggregation increases the supply chain surplus by increasing the size of each transaction and decreasing their number. Relationship aggregation is most effective when many buyers sporadically purchase small amounts at a time, but each order often has products from multiple suppliers. Thus, Grainger can increase the surplus by being a relationship aggregator for MRO products. A third party, however, does not increase the surplus by being a relationship aggregator between a few buyers and sellers for which the relationships are longer term and large. For example, Covisint failed to become a relationship aggregator in the automotive industry, especially for direct materials.

**10. Lower costs and higher quality.** A third party can increase the supply chain surplus if it provides lower cost or higher quality relative to the firm. If these benefits come from specialization and learning, they are likely to be sustainable over the longer term. A specialized third party that is further along the learning curve for some supply chain activity is likely to maintain its advantage over the long term. A common scenario, however, is one in which the third party has a low-cost location that the firm does not have. In such a situation, lower labor and overhead costs are temporary reasons for outsourcing, because if the wage differential is persistent and the third party offers none of the other advantages discussed earlier, it is best for the firm to maintain ownership and offshore production to the low-cost location.

### Key Point

A third party may be able to provide a sustainable growth of the surplus by aggregating to a higher level than the firm itself. The growth in surplus comes from aggregating capacity, inventory, inbound or outbound transportation, warehousing, procurement, information, receivables, or relationships to a level that the firm cannot achieve on its own. A growth in surplus may also occur if the third party has lower costs or higher quality because of specialization or learning.

### Factors Influencing Growth of Surplus by a Third Party

Three important factors affect the increase in surplus that a third party provides: scale, uncertainty, and the specificity of assets. If the scale is large, it is likely that sufficient economies of scale are achieved internal to the firm itself. In this case, it is unlikely that a third party can achieve further scale economies and increase the surplus. Walmart has sufficient scale in terms of its transportation needs that it achieves economies of scale on trucking by itself. Going to a third party would not increase the surplus and would result in some loss of control. In contrast, if a firm's needs do not provide sufficient economies of scale, the third party can increase the surplus by a large amount. Even though Grainger has a large number of outbound packages, given their

**TABLE 15-1** Growth in Surplus by Third Party as a Function of Scale, Uncertainty, and Specificity

		Specificity of Assets Involved in Function	
		Low	High
Firm scale	Low	High growth in surplus	Low to medium growth in surplus
	High	Low growth in surplus	No growth in surplus unless cost of capital is lower for third party
Demand uncertainty for firm	Low	Low to medium growth in surplus	Low growth in surplus
	High	High growth in surplus	Low to medium growth in surplus

geographical dispersion, it would not be able to achieve economies of scale for door-to-door delivery. A third-party package carrier adds to the surplus in this case.

The second important factor is the uncertainty of a firm's needs. If the needs are predictable, the increase in surplus from a third party is limited, especially if the firm has sufficient scale. In contrast, if the firm's needs are highly variable over time, the third party can increase the surplus through aggregation with other customers. For example, Grainger has predictable needs in terms of warehouse space required. Given sufficient scale, it owns and operates its own distribution centers. In contrast, most firms have very uncertain demand for MRO products. They prefer not to hold these items in stock and use Grainger as an intermediary.

Finally, the growth in surplus is influenced by the specificity of assets required by the third party. If the assets required are specific to a firm and cannot be used for others, a third party is unlikely to increase the surplus because all it does is move the assets from one firm to another. The third party has no opportunity to aggregate across other customers. For example, if a distributor holds inventory that is specific to a customer, the distributor is unable to aggregate it to a higher level than the customer. The presence of the distributor does not increase the surplus in this case. Similarly, if a third-party logistics provider manages a warehouse exclusively for a single firm, it has few opportunities to increase the surplus unless it can aggregate the use of management or information systems across other warehouses. In contrast, if assets (inventory or warehouses, in the previous examples) are less specific and can be used across multiple firms, a third party can increase the surplus by aggregating uncertainty across multiple customers or improving economies of scale.

One instance in which a firm may outsource to a third party even when none of the mentioned factors suggests outsourcing is shortage of capital or a third party with a much lower cost of capital. In either of these scenarios, the third party can grow the surplus by bringing lower-cost capital to the supply chain. This discussion on how and when a third party can increase the supply chain surplus is summarized in Table 15-1.

### Key Point

A firm gains the most by outsourcing to a third party if its needs are small, highly uncertain, and shared by other firms sourcing from the same third party.

### Risks of Using a Third Party

Firms must evaluate the following risks when they move any function to a third party:

1. **The process is broken.** The biggest problems arise when a firm outsources supply chain functions simply because it has lost control of the process. Keep in mind that introducing a third party into a broken supply chain process only makes it worse and harder to control. The first step should be to get the process under control, then do a cost-benefit analysis, and only then decide on outsourcing.

**2. Underestimation of the cost of coordination.** A common mistake when outsourcing is to underestimate the effort required to coordinate activities across multiple entities performing supply chain tasks. This is especially true if a firm plans to outsource specific supply chain functions to different third parties. Outsourcing functions to many third parties is feasible (and can be very effective) if the firm views being a coordinator as one of its core strengths. A good example of a strong coordinator is Cisco. However, even Cisco ran into trouble in the early 2000s and was left with a great deal of surplus inventory because of coordination problems. Another example of coordination causing problems occurred between Nike and i2 Technologies in 2000. Nike blamed its loss of \$100 million on inventory management glitches that it attributed to the supply chain planning software from i2; i2, in turn, blamed the problems on Nike's execution of the software. Clearly, insufficient coordination between the two firms played a role in this failure.

**3. Reduced customer/supplier contact.** A firm may lose customer/supplier contact by introducing an intermediary. The loss of customer contact is particularly significant for firms that sell directly to consumers but decide to use a third party to either collect incoming orders or deliver outgoing product. A good example is Boise Cascade, which outsourced all its outbound distribution to third parties. This led to a significant loss of customer contact. Boise Cascade decided to bring outbound delivery for customers located close to its distribution centers in-house. Given the high density of customers around its distribution centers, the additional gain in surplus that a third party could provide was minimal, whereas the gain from improved customer contact was significant. Boise Cascade did not bring distribution beyond this point in-house because the gain in surplus provided by a third party was significant.

**4. Loss of internal capability and growth in third-party power.** A firm may choose to keep a supply chain function in-house if outsourcing will significantly increase the third party's power. An example can be found in the electronics industry. Companies such as HP and Motorola have moved most of their manufacturing to contract manufacturers but are reluctant to move either procurement or design, even though contract manufacturers have developed both capabilities. Given the commonality of components, it can be argued that a contract manufacturer can achieve a higher level of aggregation in procurement as well as design assets. HP and Motorola, however, are reluctant to move procurement to contract manufacturers because the potential loss in power is large, whereas the aggregation gains are small given the relatively large size of both firms. Keeping part of a supply chain function in-house is also important if a complete loss of capability significantly strengthens the third party's bargaining position. The in-house capability then serves as an option that can be exercised when the need arises. The option also limits how much of the supply chain surplus the third party can keep for itself.

**5. Leakage of sensitive data and information.** Using a third party requires a firm to share demand information and, in some cases, intellectual property. If the third party also serves competitors, leakage is always a danger. Firms have often insisted on firewalls within the third party, but a firewall increases the specificity of assets, limiting the growth in surplus that the third party can provide. When leakage is an issue, especially with regard to intellectual property, firms often choose to keep the function in-house.

**6. Ineffective contracts.** Contracts with performance metrics that distort the third party's incentives often significantly reduce any gains from outsourcing. For example, cost-plus pricing of third-party services presents incentive problems even if the third party opens its books. This form of pricing eliminates incentives for the third party to innovate further to reduce costs. The onus for improvement falls back on the firm. Another example occurs when firms require suppliers or distributors to maintain a certain number of days of inventory as part of the contract. Such a contract reduces the third party's incentive to take actions that reduce inventories. In such a situation, it is better for the firm to contract on a desired service level and leave the third party more freedom with regard to the amount of inventory. The third party then has an incentive to work on reducing the inventory required to provide a given level of service.

**7. Loss of supply chain visibility.** Introducing third parties reduces the visibility of supply chain operations, making it harder for the firm to respond quickly to local customer and market demands. This loss of visibility can be particularly harmful for long supply chains.

**8. Negative reputational impact.** In many instances, actions regarding labor or the environment taken by the third party can have a significant negative impact on the reputation of the firm. Nike has had difficulty with several of its suppliers regarding labor practices and the environment. In 2008, Nike produced its first supply chain report on suppliers in China and reported several questionable labor practices, including underage workers, unpaid wages, and falsified documents. The reputational loss from actions by a supplier can be particularly damaging to firms like Nike with strong brands.

### Strategic Factors in Sourcing

Besides economic factors and risks, strategic factors must be accounted for when making sourcing decisions.

**1. Support the business strategy.** Harley-Davidson illustrates the importance of linking business strategy to the make or buy decision. To maintain its strong “Made in America” brand image, the company manufactures mostly in the United States even though cheaper components may be found overseas. An even more extreme example is Brunello Cucinelli, a successful Italian luxury brand. The company positions itself as providing outstanding artisanal Italian manufacturing and a culture of “ethical capitalism.” To support this strategy, the company has focused much of its production at Solomeo, a medieval hamlet in Umbria, Italy. At Solomeo, the company has built what the founder calls a “humanistic factory” where “employees are treated as preciously as the clothes they create.”

**2. Improve firm focus.** In today’s complex world, it is impossible for a firm to do everything. A lack of focus because a firm is doing everything in-house can be a major problem. Among the required activities, a firm must identify those that are core and provide a strategic advantage. Outsourcing all other activities helps improve focus and, thus, performance. A good example of increased outsourcing comes from the automotive industry. At one time, most auto manufacturers produced many of their components in-house. With the increasing complexity of an automobile, however, companies outsource most of their parts today, focusing instead on design, assembly, and coordination.

## 15.3 EXAMPLES OF SUCCESSFUL THIRD-PARTY SUPPLIERS

The assembly of consumer electronics is an activity that was largely performed in-house until the 1990s. Today, however, assembly is mostly outsourced by original equipment manufacturers (OEMs) such as Apple. In the 1990s, Macintosh computers were assembled at an Apple factory. Today, Apple tablets and smartphones are all assembled by electronics manufacturing service (EMS) providers such as Foxconn. A study of the evolution of the EMS industry points to why outsourcing of assembly has increased in the electronics industry and the capabilities that third party EMS providers have developed to further increase the value they provide.

EMS providers grew in the 1980s out of small job shops used by OEMs like IBM to supplement their own printed circuit board production capacity or to offload production of items such as cables that were not viewed as offering any strategic advantage. In the 1990s, most OEMs, such as IBM, Motorola, and Lucent, sold their production capacity and increasingly outsourced a large fraction of their manufacturing to the EMS providers. The initial manufacturing services offered by EMS providers included board assembly, final assembly, and testing. The outsourcing of board assembly to EMS providers made sense, given the expensive pick-and-place machines required by the surface mount technology. Although these machines were expensive, they were also flexible

enough that they could be reprogrammed to handle a variety of products. EMS providers could thus obtain better utilization of these machines by offering this service to competing OEMs. Even though each OEM was uncertain about the success of its own product, the industry as a whole had stable sales. The ability of the EMS providers to aggregate uncertainty has become more important as the life cycle of electronics products has continued to shrink.

Over time, EMS providers such as Flextronics and Celestica took the lead in adding design services to increase their perceived value to customers. They expanded from offering printed circuit board design and design-for-test to offering expertise in designing mobile phones, printers, networking, and consumer products. Flextronics claimed that one of the great benefits of having design teams under the same roof as manufacturing was that “engineers can design products that fit into our manufacturing flow and with our supply chain.”<sup>1</sup> EMS providers could also leverage their experience in designing a product for one customer across others in the same industry. For example, Celestica designed a generic “black box” for IBM automotive applications very quickly because it had done similar work for UK firms. This allowed IBM to reduce time to market to well below what it could have done on its own.<sup>2</sup>

EMS providers handle most of the component procurement for their customers. More than 95 percent of the procurement is turnkey, meaning that the EMS provider sends out the purchase order for parts.<sup>3</sup> Given the commonality of parts in the electronics industry, EMS providers could get lower prices for customers (especially compared with smaller OEMs) because of their large spending on parts. Flextronics, for example, was spending well over \$10 billion a year on parts, allowing it to get good deals from suppliers.

Over time, EMS providers have started to include warehousing and shipping in the menu of services they provide. Flextronics, for example, offers the customers the ability to “design, assemble, and distribute” their products. Given the commonality of parts and supply sources in the electronics industry, EMS providers are able to gain economies in inbound freight that are not available to a single OEM. On the outbound side, most electronics products move from the assembly plant to common ports in Europe and North America. This allows the EMS provider to add value by aggregating outbound shipping to a greater extent than any OEM.

The commonality of parts and the short life cycles with unpredictable winners for each new generation of products have allowed EMS providers to add significant value in the electronics industry. The rapid change and uncertainty of demand allows EMS providers to add value through aggregation in design, procurement, transportation, and manufacturing. An interesting question is whether the development of all these capabilities in a third party has lowered barriers to entry sufficiently in this industry to allow new entrants to compete effectively against established players. In any case, the development of EMS providers has resulted in a constant drop in prices in this industry—a big benefit to the consumer.

Whereas EMS providers have added logistics services, UPS is an example of a logistics provider that has added basic manufacturing services to further add value to its customers. In a 2010 press release, UPS discussed the establishment of an “in-house laptop repair facility for a well known computer manufacturer” near its global air hub in Louisville. In less than 24 hours, the UPS facility could “repair refurbish and return laptops to their owners.” By setting up a repair facility at its hub, not only had UPS reduced transportation relative to the manufacturer doing the repairs, but it also established the ability to aggregate such services across competitors. In another example, UPS took over the kit, pack, and ship operations for a major telecom company. As a result, 16 order processing and distribution facilities for the customer were centralized by UPS in one of its locations. This resulted in quicker processing, lower costs, and improved customer experience. Another excellent example of a firm that grows the supply chain surplus by effectively aggregating demand across customers and capacity across suppliers is Li & Fung, which

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<sup>1</sup>“The Value of Design,” *Electronics Business*, June 2003.

<sup>2</sup>Ibid.

<sup>3</sup>“OEMs Seek Single Point of Contact for SCM,” *Electronics Business*, June 2003.

has built a multibillion-dollar business helping global companies such as Reebok manage sourcing and production across many locations in the developing world. The company has been an intermediary between suppliers in the developing world and global buyers since it was founded in 1906. Li & Fung originally exported jade, porcelain, and silk from China to the United States. In the 1970s, the firm expanded its network of suppliers and is now able to get around regional trade umbrellas such as the European Union and NAFTA by sourcing appropriately. Li & Fung is an information hub that is able to link thousands of factories in 32 countries to almost a thousand customers in an optimal manner. Li & Fung reserves 30 to 70 percent of a supplier's capacity. These factories are accustomed to reliable repeat business from Li & Fung and are thus willing to commit this capacity. Li & Fung maintains detailed capability information for each factory that is used to match it to appropriate customer orders as they arrive. For its customers, Li & Fung facilitates short-lead-time production. This allows customers to observe sales trends before committing to an order. When an order arrives, Li & Fung procures yarn from one supplier, gets on the production schedule of a weaving mill, and finally farms out production of the garment to ensure that the delivery schedule is met. All this is done to minimize production cost while meeting delivery schedules. Clearly, Li & Fung is an integrator that adds to the supply chain surplus in ways that no individual customer or supplier could. The firm aggregates demand across hundreds of customers and capacity across thousands of suppliers and uses detailed information on both to match supply and demand in the most cost-effective manner.

Compared with the electronics industry, contract manufacturing for final assembly is much less prevalent in the automotive sector. Most auto companies set up their own assembly plants because product life cycles are longer, demand more stable, and it is difficult to design assembly plants that can produce a Toyota as well as a Ford. One successful contract manufacturer in the automotive industry is Magna Steyr, which is part of MAGNA International. The company's main assembly facility is in Graz, Austria. Its key success factor is the flexibility to "build up to five different vehicle types/derivatives on a single assembly line." This capability allows the company to produce low volume models for OEMs more effectively than they can on their own. In 2013, Magna Steyr assembled the Mercedes-Benz G-Class, the Peugeot RCZ, the MINI Countryman, and the MINI Paceman, each of which has relatively low sales volume, in its Graz plant.

## 15.4 TOTAL COST OF OWNERSHIP

When making the outsourcing decision or comparing suppliers, many firms make the fundamental mistake of focusing only on the quoted price, ignoring the fact that many factors affect the total cost of using a supplier. For instance, suppliers have different replenishment lead times. Does it pay to select a more expensive supplier with a shorter lead time? Or consider suppliers that have different on-time performance. Is the more reliable supplier worth the few extra pennies it charges per piece?

In each of these instances, the price charged by the supplier is only one of many factors that affect the supply chain surplus. It is important to focus on the *total cost of ownership* (TCO) when selecting suppliers. TCO includes all supply chain costs of sourcing a good or service from a particular supplier and can be considered in three "buckets"—acquisition costs, ownership costs, and post-ownership costs. Acquisition costs include all costs associated with the purchase of material from a supplier until it reaches the buyer and is ready for use. These costs include the supplier price, supplier terms affecting financing costs, taxes and duties, delivery costs, and incoming quality costs. Acquisition costs should also include the overhead of managing the relationship and planning the purchases. Ownership costs include all costs associated with the purchased part from when it arrives from the supplier to when the finished product is sold to the customer. These costs include inventory costs, warehousing costs, manufacturing or conversion costs, production quality costs, and production cycle time costs. Post-ownership costs include all costs incurred by the firm after the finished product has reached the end customer. These costs include warranty costs, environmental costs, product liability costs, and reputational costs. When scoring and assessing suppliers, one can organize the factors influencing total cost, as shown in Table 15-2.

**TABLE 15-2** Factors Influencing Total Cost of Ownership

Performance Category	Category Components	Quantifiable?
<i>Acquisition Costs</i>		
Supplier price	Labor, material, and overhead	Yes
Supplier terms	Net payment terms, delivery frequency, minimum lot size, quantity discounts	Yes
Taxes and duties	All tariffs and compliance costs	Yes
Delivery costs	All transportation costs from source to destination, packaging costs	Yes
Incoming quality costs	Cost of inspection, defectives, and rework	Yes
Management costs	Cost of managing and planning the purchase	Difficult
<i>Ownership Costs</i>		
Inventory costs	Supplier inventory, including raw material, in process and finished goods, in-transit inventory, finished goods inventory in supply chain	Yes
Warehousing cost	Warehousing and material handling costs to support additional inventory	Yes
Manufacturing cost	Cost of manufacturing associated with the sourced part	Yes
Production quality costs	Impact of sourced part on finished product quality	Difficult
Cycle time costs	Impact of sourced part on production cycle time	Yes
<i>Post-Ownership Costs</i>		
Reputation	Reputation impact of quality problems	No
Warranty and product liability costs	Warranty and product liability costs associated with sourced part	Difficult
Environmental costs	Environmental costs affected by sourced part	Difficult
Supplier capabilities	Replenishment lead time, on-time performance, flexibility, information coordination capability, design coordination capability, supplier viability	To some extent

The performance of each potential source (including in-house production) must be rated on each of these factors because all affect the total cost of ownership. It is important to consider trends that may exist especially if some of the sources are located overseas; these include exchange rates, local inflation in material and labor cost, transportation costs, and tariffs. This is especially true today, given the rapid change in these factors. Goel, Moussavi, and Srivatsan (2008) point out that producing a mid-range server in Asia in 2003 would have produced significant savings relative to producing it in the United States. Between 2005 and 2008, though, ocean freight costs increased by 135 percent, the Chinese yuan appreciated by 18 percent, and Chinese manufacturing wages went up by 44 percent. By 2008, freight and labor costs had increased enough to make production in the United States cheaper than production in Asia. Until 2008, many manufacturers viewed offshoring as a necessity, given that the offshore prices were 25 to 40 percent lower than those of local suppliers. By 2008, however, many executives realized that longer supply chains, lack of visibility, quality problems, growing transportation costs, and rising wages in developing countries made sourcing from local suppliers much more attractive. The lower transportation distance further increases the attractiveness of local suppliers from an environmental perspective. Given that a sourcing decision is unlikely to be changed quickly, it is important to include trends and scenarios (see Chapter 6) in the total cost analysis.

The importance of taking the TCO perspective has helped several companies make better decisions, whereas in other cases, a focus on the purchase price has ended up increasing the total cost. Zara is an excellent example in which the willingness to pay a higher purchase price has resulted in a much lower cost of ownership. The company chose to source its trendiest products from company-owned factories in Europe even though the acquisition cost from Europe was about 40 percent more expensive than Asia. The European factories had short design-to-product cycle times of three to four weeks instead of the three to six months from Asia. The shorter cycle times allowed Zara to meet demand for its popular products while not overproducing items that were not selling. As a result, Zara was able to increase profits by selling about 85 percent of its products at full price while the industry average was closer to 60 percent.

A similar perspective allowed Benetton to design an effective sourcing strategy when it introduced postponement (see Chapter 12) into its knit garments in the 1980s. Traditionally, knit garments were made by knitting colored thread. To lower costs, the various stages of knitting were handled by several small family enterprises. Although this process lowered cost, the entire production process took up to six months. Benetton identified a new process in which garments could be knit from undyed thread and then dyed later, while maintaining quality. As discussed in Chapter 12, this postponement of dyeing allows the supply of colors to better match demand. Although postponement was better at matching supply with demand, it had a higher production cost. With a focus on TCO, however, Benetton identified tailored postponement (see Chapter 13) to be a more effective strategy. Benetton separated the predictable base load from the unpredictable portion of demand for each color. Benetton outsourced for the predictable base load, as it had done in the past, to lower acquisition costs. The longer lead times of the suppliers did not hurt total cost because the base load always sold out. For the uncertain portion of demand, however, any mismatch of supply and demand was likely to increase total cost. Thus, Benetton opted for the higher cost production method with postponement to produce the unpredictable portion of demand close to when it was needed. Benetton performed the postponed dyeing function in-house so it could be very responsive in dyeing colors based on demand. This strategy of sourcing the predictable demand from low-cost third parties and the unpredictable portion of demand in-house using a very responsive (though high-cost) process allowed Benetton to decrease the total cost of ownership.

Mattel is an example of a company that paid significant post-ownership costs because of the action of a supplier. In 2007, the company announced several major recalls of toys made in China that were contaminated with lead paint. A subcontractor hired to paint the toys had used paint from a nonauthorized paint supplier. Mattel announced a charge of \$30 million to cover the cost of the recall. The company was also fined \$2.3 million by the Consumer Product Safety Commission. Even though the impact on its reputation is hard to quantify, Mattel clearly paid a high price for this sourcing decision, which lowered its acquisition cost.

Nike is another example of a company that worked very hard to contain the negative reputational impact of actions at its suppliers. Nike's business model is based on outsourcing its manufacturing. In the 1980s, Nike's manufacturing was in Korea and Taiwan, which were then viewed as low-cost sources. As labor costs increased in these countries, though, Nike urged its contractors to move production to Indonesia, China, and Vietnam. In the early 1990s, several reports appeared of poor working conditions and wages below Indonesia's minimum at a Nike subcontractor. After several years of protest, significant criticism, and weakness in demand, Nike started to take more decisive action in the late 1990s. Nike CEO Phil Knight announced an increase in the minimum age of workers, increased monitoring of suppliers, and the adoption of U.S. OSHA clean air standards in all supplier factories. The company performed many supplier audits and published a complete list of the factories with which it contracted. Even though these actions did increase the acquisition cost for Nike, they also helped turn around the company's reputation. Companies that outsource can learn from the Mattel and Nike experiences that accounting for post-ownership costs can be very helpful when making sourcing decisions.

### Key Point

Supplier performance should be compared based on the impact on total cost of ownership. In addition to acquisition costs, ownership and post-ownership costs should also be considered. In many instances, a higher acquisition cost is more than compensated for by lower ownership and post-ownership costs.

## 15.5 SUPPLIER SELECTION—AUCTIONS AND NEGOTIATIONS

Before selecting suppliers, a firm must decide whether to use single sourcing or multiple suppliers. Single sourcing guarantees the supplier sufficient business when the supplier must make a significant buyer-specific investment. The buyer-specific investment may take the form of plant and equipment designed to produce a part that is specific to the buyer or may take the form of expertise that needs to be developed. Single sourcing is also used in the automotive industry for parts such as seats that must arrive in the sequence of production. Coordinating such sequencing is impossible with multiple sources. As a result, auto companies have a single seat source for each plant but multiple seat sources across their manufacturing network. Having multiple sources ensures a degree of competition and also lowers risk by providing a backup should a source fail to deliver.

A good test of whether a firm has the right number of suppliers is to analyze what impact deleting or adding a supplier will have. Unless each supplier has a somewhat different role, it is likely that the supply base is too large. In contrast, unless adding a supplier with a unique and valuable capability clearly adds to total cost, the supply base may be too small.

The selection of suppliers is done using a variety of mechanisms, including offline competitive bids, reverse auctions, or direct negotiations. No matter what mechanism is used, supplier selection should be based on the total cost of using a supplier and not just the purchase price. In general, auctions are best used when the quantifiable acquisition cost is the primary component of total cost. If ownership or post-ownership costs are significant, auctions are not appropriate when selecting suppliers. In such settings, direct negotiations often lead to the best outcome. Next, we discuss some ideas to keep in mind when designing auctions.

### Auctions in the Supply Chain

An excellent discussion on auctions can be found in Krishna (2002) and Milgrom (2004). Much of our discussion summarizes some of their ideas.

In many supply chain settings, a buyer looks to outsource a supply chain function such as production or transportation. Potential suppliers are first qualified and then allowed to bid on how much they would charge to perform the function. The qualification process is important because there are multiple attributes of performance (as outlined in Table 15-2) that the buyer cares about. When conducting an auction based primarily on unit price, it is thus important for the buyer to specify performance expectations along all dimensions other than price. Setting up an auction that accounts for multiple attributes, not all of which can be precisely quantified, is difficult. Thus, the qualification process is used to identify suppliers that meet performance expectations along the non-price attributes. If the number of important non-price attributes is large, it is often best to engage in direct negotiations rather than use an auction.

From the buyer's perspective, the purpose of an auction is to get bidders to reveal their underlying cost structure so the buyer can select the supplier with the lowest costs. A commonly used mechanism that achieves this outcome is the *second-price (Vickrey) auction*. In this type of auction, each potential supplier submits a bid and the contract is assigned to the lowest bidder—but at the price quoted by the second-lowest bidder. In general, it is in the buyer's interest to

reveal all available information before bidding. If bidders perceive a lack of information, they are all likely to increase their bids to account for this lack of information.

A significant factor that must be accounted for when designing an auction is the possibility of collusion among bidders. Second-price auctions are particularly vulnerable to collusion. If there is collusion and all bidders but the lowest cost bidder raise their bids, the contract goes to the lowest-cost bidder, but at a high price. Firms must take care to ensure that no collusion occurs when using an auction.

## Basic Principles of Negotiation

Firms enter into negotiations both for supplier selection and to set the terms of the contract with an existing supplier. When the total cost of ownership has multiple components besides the cost of acquisition, negotiations generally result in a better outcome compared with the use of auctions. Negotiation is likely to result in a positive outcome only if the value the buyer places on outsourcing the supply chain function to a supplier is at least as large as the value the supplier places on performing the function for the buyer. The value that a supplier places on performing a function is influenced by its cost as well as other alternatives that are available for its existing capacity. Similarly, the value that the buyer places is influenced by the cost of performing the function in-house and the price available from alternative suppliers. The difference between the values of the buyer and seller is referred to as the *bargaining surplus*. The goal of each negotiating party is to ideally create a situation in which the surplus grows, thus increasing the size of the pie they have to share.

An excellent discussion on negotiations is available in Thompson (2005). We mention some of the highlights from her discussion here. The first recommendation is to have a clear idea of one's own value and as good an estimate of the third party's value as possible. A good estimate of the bargaining surplus improves the chance of a successful outcome. Suppliers of Toyota have often mentioned that "Toyota knows our costs better than we do," which leads to better negotiations. The second recommendation is to look for a fair outcome based on equally or equitably dividing the bargaining surplus or dividing it based on needs. Here, equity refers to a division of the surplus in proportion to the contribution by each party.

The key to a successful negotiation, however, is to make it a win-win outcome that grows the surplus. It is impossible to obtain a win-win outcome if the two parties are negotiating on a single dimension, such as price. In this setting, one party can only "win," at the expense of the other. To create a win-win negotiation, the two parties must identify more than one issue to negotiate. Identifying multiple issues allows the opportunity to expand the pie if the two parties have different preferences. This is often easier than it seems in a supply chain setting, especially if both parties focus on the total cost of ownership. A buyer focused on TCO cares not just about the acquisition cost, but also about responsiveness and quality (two of the dimensions identified in Table 15-2). If the supplier finds it harder to lower the purchase price but easier to reduce the response time, there is an opportunity for a win-win resolution, in which the supplier offers better responsiveness without changing the price.

An excellent example of a win-win outcome arises from a manufacturer of water treatment equipment whose focus on TCO allowed it to reduce its own production costs without changing the acquisition cost from the supplier. The company sourced specialty steel from a monopolistic supplier and was looking to reduce costs. The supplier's bargaining power (given its monopoly position) diminished any ability to drive down the purchase price for the steel. A focus on purchase price would probably have ended all negotiations. The water treatment manufacturer studied its production process and identified a method of decreasing cost of ownership without increasing the cost for the supplier. The steel was supplied in the form of sheets of a given size. These sheets were then cut into required sizes by the manufacturer before assembly. A study of the supplier's process indicated that the supplier would not mind changing the size of the sheet being cut as long as it did not increase the total number of cuts. The water treatment

manufacturer identified three different sheet sizes that, if supplied, would reduce the number of cuts required at its plant before assembly. The supplier readily agreed to cut its sheets into the three required sizes, because this change did not increase the total number of cuts. The water treatment manufacturer had originally run three shifts for metal cutting and two for assembly. After the supplier changed the size of sheets supplied, the manufacturer was able to reduce metal cutting to two shifts. The negotiation produced an outcome in which the supplier did not decrease the supply price but the buyer was able to reduce total cost. Taking all dimensions of TCO into account often allows for more successful negotiations during sourcing because it offers multiple opportunities to create win-win outcomes.

## 15.6 SHARING RISK AND REWARD IN THE SUPPLY CHAIN

In this chapter so far, we have emphasized the fact that all sourcing decisions should be made with the goal of growing the supply chain surplus. In practice, however, many firms care less about growing the surplus and more about what share of the surplus they are able to capture. As firms gain greater power in a supply chain, they often attempt to capture a greater share of the surplus while pushing more risk onto their supply chain partners. In this section, we focus on the downsides of focusing on a firm's local interest at the expense of the supply chain surplus. We also suggest some approaches that can be used to counter the downsides of local optimization.

### Sharing Risk to Grow Supply Chain Profits

Independent actions taken by two parties in a supply chain often result in profits that are lower than those that could be achieved if the supply chain were to coordinate its actions with a common objective of maximizing supply chain profits rather than individual firm profits. As firms get stronger, they tend to push more risk on to supply chain partners while keeping a large margin for themselves. A classic example of such an approach is the action taken by Mattel in 1999 in response to adverse outcomes in 1998. Until 1998, Mattel allowed its retailers to place two orders for the Christmas season. Mattel delivered the first order before the Thanksgiving weekend; retailers then placed their second order after observing sales over that weekend. The weekend sales allowed retailers to get a much better forecast for the Christmas season before placing the second order. In 1998, sales over the Thanksgiving weekend were soft and many retailers decided not to place a second order. As a result, Mattel reported a \$500 million sales shortfall in the last weeks of the year. Having been burned because of its willingness to absorb the risk of the second order, Mattel changed its policy for 1999. It now required retailers to place their entire order before Thanksgiving and the company would take no reorders in December. Mattel announced that the new policy would allow the company to “tailor production more closely to demand and avoid building inventory for orders that don't come.”

The actions of Mattel amounted to shifting risk from Mattel to the retailers. Whereas Mattel absorbed some of the forecast uncertainty when retailers were allowed a follow-up order in December, forcing retailers to place their orders before Thanksgiving pushed all the risk of forecast error onto them. This action by Mattel (seemingly taken because of its self-interest) clearly hurts retailers. We now argue that it also hurts Mattel. Given demand uncertainty, a manufacturer like Mattel wants the retailer to carry a large inventory of its product to ensure that any surge in demand can be satisfied. The retailer, on the other hand, loses money on any unsold inventory. As a result, the retailer prefers to carry a lower level of inventory, especially when it must absorb the entire risk of a forecast error. This tension leads to a supply chain outcome that hurts both the retailer and the manufacturer, as illustrated in Example 15-1 (see worksheet *Example15-1* in workbook *Chapter15-examples*).

**EXAMPLE 15-1** Impact of Local Optimization

Consider a music store that sells compact discs. The supplier manufactures compact discs at \$1 per unit and sells them to the music store at \$5 per unit. The retailer sells each disc to the end consumer at \$10. At this retail price, market demand is normally distributed, with a mean of 1,000 and a standard deviation of 300. Any leftover discs at the end of the sale period are worthless. How many discs should an independent retailer order? What are the supply chain profits with an independent retailer? If the manufacturer and the retailer are vertically integrated (they are a single firm), how many discs should the retailer order? What are the supply chain profits when the manufacturer and retailer are a single firm?

**Analysis:**

We first consider the case of the independent retailer. The retailer has a margin of \$5 per disc and can potentially lose \$5 for each unsold disc. The retailer thus has a cost of overstocking  $C_o = \$5$  and a cost of understocking  $C_u = \$5$ . Using Equation 13.1, it is optimal for the retailer to aim for a service level of  $5/(5 + 5) = 0.5$  and order  $NORMINV(0.5, 1000, 300) = 1,000$  discs. From Equation 13.3, the retailer's expected profits are \$3,803, and the manufacturer makes \$4,000 from selling 1,000 discs. The total supply chain profit with an independent retailer is thus  $\$3,803 + \$4,000 = \$7,803$ .

Now, consider the case in which the supply chain is vertically integrated. The supply chain has a margin of  $\$10 - \$1 = \$9$  per disc and can potentially lose \$1 for each unsold disc. The supply chain thus has a cost of overstocking  $C_o = \$1$  and a cost of understocking  $C_u = \$9$ . Using Equation 13.1, it is optimal for the supply chain to aim for a service level of  $9/(1 + 9) = 0.9$  and order  $NORMINV(0.9, 1000, 300) = 1,384$  discs. From Equation 13.3, the supply chain's expected profits are \$8,474.

Thus, the vertically integrated supply chain makes \$670 more than when the retailer makes the ordering decision independently.

As discussed in Chapter 11, double marginalization reduces supply chain profits because the supply chain margin is divided between the two parties, and each stage makes its decisions considering only its own margin. We now discuss several other instances in which double marginalization leads to a loss in supply chain performance in the presence of demand uncertainty.

An independent retailer makes its buying decision before demand is realized and thus bears all the demand uncertainty. If demand is less than the retailer's inventory, the retailer must liquidate unsold product at a discount. Given uncertain demand, the retailer decides on the purchase quantity based on its margin and the cost of overstocking, as discussed in Chapter 13. The retailer's margin, however, is lower than the contribution margin for the entire supply chain, whereas its cost of overstocking is higher than that for the entire supply chain. As a result, the retailer is conservative and aims for a lower level of product availability than is optimal for the supply chain leading to a loss of supply chain surplus. As Example 15-1 illustrates, if the retailer absorbs all the risk of forecast error while getting only a portion of the margin (\$4 in this example, compared with a supply chain margin of \$9), the retailer's ordering decision lowers supply chain profits compared with those of a vertically integrated supply chain.

From our discussion, it seems clear that Mattel's actions—in which it pushed all the risk onto retailers—clearly hurt supply chain profits because retailers were more conservative than they would have been when Mattel shared some risk. The conservative approach of the retailers did not allow the supply chain to take advantage of any upside in demand, thus reducing supply chain profits.

### Key Point

The absence of risk sharing in a supply chain results in locally optimal decisions that decrease the total supply chain profits. In the absence of risk sharing, retailers aim for a lower level of product availability than would be required to maximize supply chain profits.

Given that we have identified the problem when risk is not shared, we now focus on identifying potential solutions that allow for risk sharing in a way that increases supply chain profits. To improve overall profits, the supplier must share risk in a way that encourages the buyer to purchase more and increase the level of product availability. This requires the supplier to share in some of the buyer's demand uncertainty. The following three approaches to risk sharing increase overall supply chain profits:

1. Buybacks or returns
2. Revenue sharing
3. Quantity flexibility

We illustrate each of the three approaches using the story in Example 15-1 of the music store. We discuss the performance of each approach in terms of the following three questions.

1. How will risk sharing affect the firm's profits and total supply chain profits?
2. Will risk sharing introduce any information distortion?
3. How will risk sharing influence supplier performance along key performance measures?

**RISK SHARING THROUGH BUYBACKS** A buyback or returns clause allows a retailer to return unsold inventory up to a specified amount, at an agreed-upon price. In this case, the supplier is sharing risk by agreeing to buy back unsold inventory at the retailer. In a *buyback contract*, the manufacturer specifies a wholesale price  $c$  along with a buyback price  $b$  at which the retailer can return any unsold units at the end of the season. We assume that the manufacturer can salvage  $s_M$  for any units that the retailer returns. The manufacturer has a cost of  $v$  per unit produced. The retail price is  $p$ .

The optimal order quantity  $O^*$  for a retailer in response to a buyback contract is evaluated using Equations 13.1 and 13.2, where the salvage value for the retailer is  $s = b$ . The cost of overstocking for the retailer is given by  $C_o = c - b$ , and the cost of understocking for the retailer is given by  $C_u = p - c$ . Using Equation 13.1, the optimal service level that the retailer targets is thus given by  $CSL^* = (p - c)/(p - b)$ . Using Equation 13.2, the optimal order size by the retailer is given by  $O^* = NORMINV(CSL^*, \mu, \sigma)$ . The expected retailer profit is evaluated using Equation 13.3 with the salvage value  $s$  equal to the buyback price  $b$ . The expected profit at the manufacturer depends on the overstock at the retailer (evaluated using Equation 13.4) that is returned. We obtain

$$\begin{aligned} \text{Expected manufacturer profit} &= O^* (c - v) - (b - s_M) \\ &\quad \times \text{expected overstock at retailer} \end{aligned}$$

We illustrate the impact of buybacks on supply chain profits in Example 15-2 (see worksheet *Example15-2*).

### EXAMPLE 15-2 Impact of Risk Sharing Through Buybacks

We return to the music store in Example 15-1 with all data as specified. Assume that the supplier agrees to buy back any unsold discs for \$3 even though any leftover discs at the end of the sale

period are worthless. With the buyback clause, how many discs should an independent retailer order? What are the supply chain profits with a buyback clause?

### Analysis:

With a buyback clause as specified, the retailer has a salvage value of \$3 for each unsold unit. Given the wholesale price of \$5 and a retail price of \$10, the retailer thus has a cost of overstocking,  $C_o = \$5 - \$3 = \$2$  and a cost of understocking  $C_u = \$10 - \$5 = \$5$ . Using Equation 13.1, it is optimal for the retailer to aim for a service level of  $5/(2 + 5) = 0.71$  and order 1,170 [=  $NORMINV(5/7, 1000, 300)$ ] discs. From Equation 13.3, the retailer's expected profits are \$4,286. Given an expected overstock of 223 units (using Equation 13.4), the manufacturer's expected profit is \$4,011 [=  $1170 \times (5 - 1) - (223 \times 3)$ ]. The total supply chain profit with buybacks is thus \$4,286 + \$4,011 = \$8,297

Observe that risk sharing using a buyback clause for \$3 increases profits for the retailer as well as the manufacturer (and the supply chain as a whole) compared with Example 15-1, in which there was no risk sharing.

Example 15-2 illustrates that risk sharing through a suitably designed buyback clause can increase manufacturer profits (relative to the case without risk sharing) even though the retailer is compensated for any unsold inventory. Risk sharing by the manufacturer always increases the retailer's profits increase because the retailer's cost of overstocking has decreased. Despite buying back unsold inventory at \$3, the supplier's profits increase in Example 15-2 because the retailer, on average, sells more product (on which the supplier makes \$5 per unit). Buyback contracts are most effective for products with a low variable cost, such as music, software, books, magazines, and newspapers.

Table 15-3 (which can be constructed using worksheet *Example15-2*) shows supply chain profits for different values of wholesale and buyback prices. Observe that the use of buyback contracts increases total supply chain profits by about 20 percent when the wholesale price is \$7 per disc. For a fixed wholesale price, increasing the buyback price always increases retailer profits. In general, there exists a positive buyback price that is a fraction of the wholesale price, at which the manufacturer makes a higher profit compared to offering no buyback. Also observe that buybacks increase profits for the manufacturer more as the manufacturer's margin increases. In Table 15-3, buybacks are found to be more helpful to the manufacturer when the wholesale

**TABLE 15-3** Order Sizes and Profits in Music Supply Chain Under Different Buyback Contracts

Wholesale Price $c$	Buyback Price $b$	Optimal Order Size for Music Store	Expected Profit for Music Store	Expected Returns to Supplier	Expected Profit for Supplier	Expected Supply Chain Profit
\$5	\$0	1,000	\$3,803	120	\$4,000	\$7,803
\$5	\$2	1,096	\$4,090	174	\$4,035	\$8,125
\$5	\$3	1,170	\$4,286	223	\$4,009	\$8,295
\$6	\$0	924	\$2,841	86	\$4,620	\$7,461
\$6	\$2	1,000	\$3,043	120	\$4,761	\$7,804
\$6	\$4	1,129	\$3,346	195	\$4,865	\$8,211
\$7	\$0	843	\$1,957	57	\$5,056	\$7,013
\$7	\$4	1,000	\$2,282	120	\$5,521	\$7,803
\$7	\$6	1,202	\$2,619	247	\$5,732	\$8,351

price is \$7 relative to when the wholesale price is \$5. Thus, the greater the manufacturer's margin, the more the manufacturer stands to benefit through the use of some risk-sharing mechanism such as buybacks.

For a fixed wholesale price, as the buyback price increases, the retailer orders more and also returns more. In our analysis in Table 15-3, though, we have not considered the cost associated with a return. As the cost associated with a return increases, buyback contracts become less attractive because the cost of returns reduces supply chain profits. If return costs are high, buyback contracts can reduce the total profits of the supply chain far more than is the case without any buyback.

In 1932, Viking Press was the first book publisher to accept returns. Today, buyback contracts are common in the book industry, and publishers accept unsold books from retailers. To minimize the cost associated with a return, retailers do not have to return the book, only the cover. When publishers can verify retailer sales electronically, nothing must be returned. The goal in either case is for the publisher to get proof that the book did not sell while reducing the cost of the return. Over the years, considerable debate has taken place about the impact of publishers' returns policy on profits in the industry. Our discussion provides some justification for the approach taken by the publishers.

In some instances, manufacturers use holding-cost subsidies or price protection to share risk and encourage retailers to order more. With *holding-cost subsidies*, manufacturers pay retailers a certain amount for every unit held in inventory over a given period. Holding-cost subsidies are prevalent in automotive supply chains. In the high-tech industry, in which products lose value rapidly, manufacturers share the risk of product becoming obsolete by providing *price support* to retailers. Many manufacturers guarantee that in the event that they drop prices, they will also lower prices for all inventories that the retailer is currently carrying and compensate the retailer accordingly. As a result, the cost of overstocking at the retailer is limited to the cost of capital and physical storage and does not include obsolescence, which can be more than 100 percent a year for high-tech products. The retailer thus increases the level of product availability in the presence of price support. Both holding-cost subsidies and price support are forms of buyback.

A downside to the buyback clause (or any equivalent practice, such as holding-cost subsidy or price support) is that it leads to surplus inventory that must be salvaged or disposed. The task of returning unsold product increases supply chain costs. The cost of returns can be eliminated if the manufacturer gives the retailer a markdown allowance and allows it to sell the product at a significant discount. Publishers today generally do not ask retailers to return unsold books; instead, they give a markdown allowance for them. Retailers then mark them down and sell them for a considerable discount.

For a given level of product availability at the retailer, the presence of a buyback clause can also hurt sales because it leads the retailer to exert less effort to sell than it would without buybacks. The reduction in retailer effort in the presence of buyback occurs because its loss from unsold inventory is higher when there is no buyback, leading to a higher sales effort for products with no buyback. The supplier can counter the reduction in sales effort by limiting the amount of buyback permitted.

The structure of a buyback clause leads to the entire supply chain reacting to the order placed by the retailer and not to actual customer demand. If a supplier is selling to multiple retailers, it produces based on the orders placed by each retailer. Each retailer bases its order on its cost of overstocking and understocking (see Chapter 13). After actual sales materialize, unsold inventory is returned to the supplier separately from each retailer. As a result, the structure of the buyback clause increases information distortion when a supplier is selling to multiple retailers. At the end of the sales season, however, the supplier does obtain information on actual sales. Information distortion is driven primarily by the fact that inventory is disaggregated at the retailers based on an ordering decision made when demand is uncertain. If inventory is produced by the supplier and sent out only as needed to the retailers, information distortion can be reduced.

With more responsive production and centralized inventory, the supplier can exploit independence of demand across retailers to carry a lower level of inventory. In practice, however, most buyback contracts have decentralized inventory at retailers. As a result, there is a high level of information distortion.

**RISK SHARING THROUGH REVENUE SHARING** In *revenue-sharing* contracts, the manufacturer charges the retailer a lower wholesale price  $c$  (compared with the case without risk sharing), but shares a fraction  $f$  of the retailer's revenue. In this case, the manufacturer is sharing risk because the retailer's cost is lower (than without risk sharing) if demand is low. Even if no returns are allowed, the lower wholesale price decreases the cost to the retailer in case of an overstock. The retailer thus increases the level of product availability, resulting in higher profits for both the manufacturer and the retailer when revenue sharing is suitably designed.

Assume that the manufacturer has a production cost  $v$ ; the retailer charges a retail price  $p$  and can salvage any leftover units for  $s_R$ . The optimal order quantity  $O^*$  ordered by the retailer is evaluated using Equations 13.1 and 13.2, where the cost of understocking is  $C_u = (1 - f)p - c$  and the cost of overstocking is  $C_o = c - s_R$ . We thus obtain

$$CSL^* = \text{probability}(\text{demand} \leq O^*) = \frac{C_u}{C_u + C_o} = \frac{(1 - f)p - c}{(1 - f)p - s_R}$$

The manufacturer obtains the wholesale price  $c$  for each unit purchased by the retailer and a share of the revenue for each unit sold by the retailer. The expected overstock at the retailer is obtained using Equation 13.4. The manufacturer's profits are thus evaluated as

$$\begin{aligned} \text{Expected manufacturers profits} &= (c - v)O^* \\ &\quad + fp(O^* - \text{expected overstock at retailer}) \end{aligned}$$

The retailer pays a wholesale price  $c$  for each unit purchased and obtains a revenue of  $(1 - f)p$  for each unit sold and a revenue of  $s_R$  for each unit overstocked. The retailer's expected profit is thus evaluated as

$$\begin{aligned} \text{Expected retailer profit} &= (1 - f)p(O^* - \text{expected overstock at retailer}) \\ &\quad + s_R \times \text{expected overstock at retailer} - cO^* \end{aligned}$$

We illustrate the impact of revenue sharing on supply chain profits using Example 15-3 (see worksheet *Example15-3*).

### EXAMPLE 15-3 Impact of Risk Sharing Through Revenue Sharing

We return to the music store in Example 15-1 with all data as specified. Assume that the supplier agrees to a revenue sharing contract under which the retailer is charged only \$1 for each disc, with the manufacturer getting 45 percent of the retail revenues. Given the retail price of \$10, the manufacturer gets \$4.50 for each disc sold while the retailer keeps \$5.50. With the revenue-sharing clause, how many discs should an independent retailer order? What are the supply chain profits with a revenue-sharing clause?

#### Analysis:

With a revenue-sharing clause as specified, we have  $c = \$1$ ,  $p = \$10$ ,  $s_R = 0$ , and a revenue share fraction  $f = 0.45$ . The manufacturer has a production cost of  $v = \$1$ . The music store thus has a cost of overstocking of  $C_o = c - s_R = 1 - 0 = \$1$  and a cost of understocking of  $C_u = (1 - f)p - c = (1 - 0.45) \times 10 - 1 = \$4.50$ . The music store targets a service

level of  $CSL^* = 4.5/(4.5 + 1) = 0.818$ , or 81.8 percent (see Equation 13.1) and orders 1,273 [=  $NORMINV(4.5/5.5, 1000, 300)$ ] discs. Observe that this is much larger than the 1,000 discs ordered in Example 15-1, when the wholesale price was \$5 and there was no revenue sharing. The increase in order size occurs because the retailer loses only \$1 per unsold disc (instead of \$5 per disc without revenue sharing), while making a margin of \$4.50 for each disc that sells.

Given an order of 1,273 discs, the retailer has an expected overstock of 302 discs (use Equation 13.4). As a result, the expected manufacturer's profit =  $(c - v)O^* + fp(O^* - \text{expected overstock}) = (1 - 1) \times 1273 + 0.45 \times 10 \times (1273 - 302) = \$4,369$ . The expected retailer's profit =  $(1 - f)p(O^* - \text{expected overstock at retailer}) + s_R \times \text{expected overstock at retailer} - cO^* = (1 - 0.45) \times 10 \times (1273 - 302) + 0 \times 302 - 1 \times 1273 = \$4,068$ . The total supply chain

Observe that risk sharing using a revenue sharing clause with a \$1 wholesale price and a 45 percent share for the supplier increases profits for the retailer as well as the manufacturer (and the supply chain as a whole) compared with Example 15-1, in which there was no risk sharing.

Table 15-4 (constructed using worksheet *Example15-3* in spreadsheet *Chapter15-examples*) provides the outcome in terms of order sizes and profits for different wholesale prices and revenue-sharing fractions  $f$ . From Tables 15-3 and 15-4, observe that revenue sharing allows both the manufacturer and retailer to increase their profits in the absence of buybacks compared with the case in which the wholesaler sells for a fixed price of \$5 without buybacks. Recall that when charging a wholesale price of \$5, the supplier makes profit of \$4,000 and the music store makes a profit of \$3,803 (see Table 15-3).

Revenue-sharing contracts also result in lower retailer effort compared with the case in which the retailer pays an upfront wholesale price and keeps the entire revenue from a sale. The drop in effort results because the retailer gets only a fraction of the revenue from each sale. One advantage of revenue-sharing contracts over buyback contracts is that no product needs to be returned, thus eliminating the cost of returns. Revenue-sharing contracts are best suited for products with low variable cost and a high cost of return. A good example of revenue-sharing contracts was implemented between Blockbuster video rentals and movie studios for videos. A studio sold each cassette to Blockbuster at a low price and then shared in the revenue generated from each rental. Given the low price, Blockbuster purchased many copies, resulting in more rentals and higher profits for both Blockbuster and the studio.

The revenue-sharing contract does require an information infrastructure that allows the supplier to monitor sales at the retailer. Such an infrastructure can be expensive to build. As a result, revenue-sharing contracts may be difficult to manage for a supplier selling to many small buyers.

As in buyback contracts, revenue-sharing contracts also result in the supply chain producing to retailer orders rather than to actual consumer demand. This information distortion results in excess inventory in the supply chain and a greater mismatch between supply and demand. The information distortion increases as the number of retailers to which the supplier sells grows. As

**TABLE 15-4** Order Sizes and Profits in Music Supply Chain Under Different Revenue-Sharing Contracts

Wholesale Price $c$	Revenue-Sharing Fraction $f$	Optimal Order Size for Music Store	Expected Overstock at Music Store	Expected Profit for Music Store	Expected Profit for Supplier	Expected Supply Chain Profit
\$1	0.30	1,320	342	\$5,526	\$2,934	\$8,460
\$1	0.45	1,273	302	\$4,064	\$4,367	\$8,431
\$1	0.60	1,202	247	\$2,619	\$5,732	\$8,350
\$2	0.30	1,170	223	\$4,286	\$4,009	\$8,295
\$2	0.45	1,105	179	\$2,881	\$5,269	\$8,150
\$2	0.60	1,000	120	\$1,521	\$6,282	\$7,803

with buyback contracts, information distortion from revenue-sharing contracts can be reduced if retailers reserve production capacity or inventory at the supplier rather than buying product and holding it in inventory themselves. This allows aggregation of the variability across multiple retailers, and the supplier must hold a lower level of capacity or inventory. In practice, however, most revenue-sharing contracts are implemented with the retailer buying and holding inventory.

**RISK SHARING USING QUANTITY FLEXIBILITY** Under *quantity flexibility contracts*, the manufacturer allows the retailer to change the quantity ordered (within limits) after observing demand. If a retailer orders  $O$  units, the manufacturer commits to providing up to  $Q = (1 + \alpha)O$  units, whereas the retailer is committed to buying at least  $Q = (1 + \beta)O$  units. Both  $\alpha$  and  $\beta$  are between 0 and 1. The retailer can purchase anywhere between  $q$  and  $Q$  units, depending on the demand it observes. Quantity flexibility contracts are similar in spirit to the contract that Mattel offered its retailers prior to 1999. In quantity flexibility contracts the manufacturer shares risk by allowing the retailer to adjust its order as better market information is received. Because no returns are required, these contracts can be more effective than buyback contracts when the cost of returns is high. When the supplier is selling to multiple retailers, these contracts are more effective than buyback contracts because they allow the supplier to aggregate uncertainties across multiple retailers and thus lower the level of excess inventory. Quantity flexibility contracts increase the average amount the retailer purchases and may increase total supply chain profits when structured appropriately.

Assume that the manufacturer incurs a production cost of  $\$v$  per unit and charges a wholesale price of  $\$c$  from the retailer. The retailer, in turn, sells to customers for a price of  $\$p$ . The retailer salvages any leftover units for  $s_r$ . The manufacturer salvages any leftover units for  $s_m$ . If retailer demand is normally distributed, with a mean of  $\mu$  and a standard deviation of  $\sigma$  we can evaluate the impact of a quantity flexibility contract. If the retailer orders  $O$  units, the manufacturer is committed to supplying  $Q$  units. As a result, we assume that the manufacturer produces  $Q$  units. The retailer purchases  $q$  units if demand  $D$  is less than  $q$ ,  $D$  units if demand  $D$  is between  $q$  and  $Q$ , and  $Q$  units if demand  $D$  is greater than  $Q$ . In the following formulas,  $F$  is the standard normal cumulative distribution function and  $f$  is the standard normal density function discussed in Appendix 12A in Chapter 12. We thus obtain

$$\begin{aligned} \text{Expected quantity purchased by retailer, } Q_R &= qF(q) + Q[1 - F(Q)] \\ &\quad + \mu \left[ F_s \left( \frac{Q - \mu}{\sigma} \right) - F_s \left( \frac{q - \mu}{\sigma} \right) \right] \\ &\quad - \sigma \left[ f_s \left( \frac{Q - \mu}{\sigma} \right) - f_s \left( \frac{q - \mu}{\sigma} \right) \right] \end{aligned}$$

$$\begin{aligned} \text{Expected quantity sold by retailer, } D_R &= Q[1 - F(Q)] \\ &\quad + \mu F_s \left( \frac{Q - \mu}{\sigma} \right) - \sigma f_s \left( \frac{Q - \mu}{\sigma} \right) \end{aligned}$$

$$\text{Expected overstock at manufacturer} = Q_R - D_R$$

$$\text{Expected retailer profit} = D_R \times p + (Q_R - D_R)s_r - Q_R \times c$$

$$\text{Expected manufacturer profit} = Q_R \times c + (Q - Q_R)s_m - Q \times v$$

We illustrate the impact of quantity flexibility on supply chain profits using Example 15-4 (see worksheet *Example15-4*).

#### EXAMPLE 15-4 Impact of Risk Sharing Through Quantity Flexibility

We return to the music store in Example 15-1 with all data as specified. The retailer is charged \$5 for each disc and has a retail price of \$10. Assume that the supplier agrees to a quantity flexibility

contract where the supplier agrees to  $\alpha = 0.05$  and  $\beta = 0.05$ . For this contract, the retailer decides to place an order for 1,017 units. With the quantity flexibility clause, how many discs does the independent retailer expect to purchase? How many discs does the retailer expect to sell? What are the supply chain profits with a quantity flexibility clause?

**Analysis:**

In this case, we have  $v = \$1$ ,  $c = \$5$ ,  $p = \$10$ ,  $s_R = 0$ , and  $s_M = 0$ . With the quantity flexibility clause as specified, and an order for  $O = 1,017$  from the retailer, the manufacturer is committed to supplying any quantity between  $q = (1 - \beta)O = (1 - 0.05) \times 1017 = 966$  units and  $Q = (1 + \alpha)O = (1 + 0.05) \times 1017 = 1,068$  units. We thus obtain

Expected quantity purchased by retailer,  $Q_R = 1,015$  units

Expected quantity sold by retailer,  $D_R = 911$  units

Expected overstock at retailer =  $Q_R - D_R = 1,015 - 911 = 104$  units

Expected retailer profit =  $D_R \times p + (Q_R - D_R)s_R - Q_R \times c$   
 $= 911 \times 10 + (1015 - 911) \times 0 - 1015 \times 5 = \$4,038$

Expected manufacturer profit =  $Q_R \times c + (Q - Q_R)s_M - Q \times v$   
 $= 1015 \times 5 + (1068 - 1015) \times 0 - 1068 \times 1 = \$4,007$

Given an order of 1,017 discs (which is adjusted between 966 and 1,068 based on actual demand), the total supply chain profit =  $4,038 + 4,007 = \$8,045$ .

Observe that risk sharing using a quantity flexibility clause with a flexibility of 5 percent above and below the order quantity increases profits for the retailer as well as the manufacturer (and the supply chain as a whole) compared with Example 15-1, in which there was no risk sharing.

With a quantity flexibility clause, the retailer is able to take advantage of market intelligence so the amount finally purchased by the retailer is more in line with actual demand. The better matching of supply and demand results in higher profits for the retailer. If the supplier has access to some flexible and responsive capacity, it can produce the uncertain part of the order after the retailer order is finalized while producing the base load ( $q$  units) using an inexpensive production method. This tailoring of production allows the supplier to reduce overall costs. A quantity flexibility contract is particularly effective if a supplier is selling to multiple retailers with independent demand because it allows uncertainties to be aggregated by the supplier.

In Table 15-5, we show the impact of different quantity flexibility contracts on profitability for the music supply chain when demand is normally distributed, with a mean of  $\mu = 1,000$

**TABLE 15-5** Profits at Music Supply Chain Under Different Quantity Flexibility Contracts

$\alpha$	$\beta$	Wholesale Price $c$	Order Size $O$	Expected Purchase by Retailer	Expected Sale by Retailer	Expected Profits for Retailer	Expected Profits for Supplier	Expected Supply Chain Profit
0.00	0.00	\$5	1,000	1,000	880	\$3,803	\$4,000	\$7,803
0.05	0.05	\$5	1,017	1,015	911	\$4,038	\$4,006	\$8,044
0.20	0.20	\$5	1,047	1,023	967	\$4,558	\$3,858	\$8,416
0.00	0.00	\$6	924	924	838	\$2,841	\$4,620	\$7,461
0.20	0.20	\$6	1,000	1,000	955	\$3,547	\$4,800	\$8,347
0.30	0.30	\$6	1,021	1,006	979	\$3,752	\$4,711	\$8,463
0.00	0.00	\$7	843	843	786	\$1,957	\$5,056	\$7,013
0.20	0.20	\$7	947	972	936	\$2,560	\$5,666	\$8,226
0.40	0.40	\$7	1,000	1,000	987	\$2,873	\$5,600	\$8,473

and a standard deviation of  $\sigma = 300$  (see worksheet *Example15-4* in spreadsheet *Chapter15-examples*). We assume a wholesale price of  $c = \$5$  and a retail price of  $p = \$10$ . All contracts considered are such that  $\alpha = \beta$ . The results in Table 15-5 are built in two steps. We first fix  $\alpha$  and  $\beta$  (say  $\alpha = \beta = 0.2$ ). The next step is to identify the optimal order size for the retailer. This is done using Excel by selecting an order size that maximizes expected retailer profits given  $\alpha$  and  $\beta$ . For example, when  $\alpha = \beta = 0.05$  and  $c = \$5$ , retailer profits are maximized for an order size of  $O = 1,017$ . For this order size, we obtain a supplier commitment to deliver up to  $Q = (1 + 0.05) \times 1,017 = 1,068$  and a retailer commitment to buy at least  $q = (1 - 0.05) \times 1,017 = 966$  discs. In our analysis, we assume that the supplier produces  $Q = 1,068$  discs and sends the precise number (between 966 and 1,068) demanded by the retailer. Such a policy results in retailer profits of \$4,038 and supplier profits of \$4,006.

From Table 15-5, observe that quantity flexibility contracts allow both the manufacturer and the retailer to increase their profits. Observe that as the manufacturer increases the wholesale price, it is optimal for it to offer greater quantity flexibility to the retailer.

Quantity flexibility contracts are common for components in the electronics and computer industries. In the previous discussion, we considered fairly simple quantity flexibility contracts. Benetton has used sophisticated quantity flexibility contracts with its retailers successfully to increase supply chain profits. We describe such a contract in the context of colored knit garments (see Heskett and Signorelli, 1984).

Seven months before delivery, Benetton retailers were required to place their orders. Consider a retailer placing an order for 100 sweaters each in red, blue, and yellow. One to three months before delivery, retailers could alter up to 30 percent of the quantity ordered in any color and assign it to another color. The aggregate order, however, could not be adjusted at this stage. Potentially, the retailer could change the order to 70 red, 70 blue, and 160 yellow sweaters. After the start of the sales season, retailers were allowed to order up to 10 percent of their previous order in any color. Potentially, then, the retailer could order another 30 yellow sweaters. In this quantity flexibility contract, Benetton retailers had a flexibility of up to 10 percent on the aggregate order across all colors and of about 40 percent for individual colors. Retailers could increase the aggregate quantity ordered by up to 10 percent, and the quantity for any individual color could be adjusted by up to 40 percent. This flexibility is consistent with the fact that aggregate forecasts are more accurate than forecasts for individual colors. As a result, retailers could better match product availability with demand. The guaranteed portion of the order was manufactured by Benetton using an inexpensive but long-lead-time production process. The flexible part of the order (about 35 percent) was manufactured using postponement. The result was a better matching of supply and demand at lower cost than in the absence of quantity flexibility. The quantity flexibility contract allowed both the retailers and Benetton to increase their profits.

The quantity flexibility contract requires either inventory or excess flexible capacity to be available at the supplier. If the supplier is selling to multiple retailers with independent demand, the aggregation of inventory leads to a smaller surplus inventory (see Chapter 12) with a quantity flexibility contract compared to either a buyback or revenue-sharing contract. Inventories can be further reduced if the supplier has excess flexible capacity. Quantity flexibility contracts are thus preferred for products with high marginal cost or when surplus capacity is available. To be effective, quantity flexibility contracts require the retailer to be good at gathering market intelligence and improving its forecasts closer to the point of sale.

Relative to buyback and revenue-sharing contracts, quantity flexibility contracts have less information distortion. Consider the case with multiple retailers. With a buyback contract, the supply chain must produce based on the retailer orders that are placed well before actual demand arises. This leads to surplus inventory being disaggregated at each retailer. With a quantity flexibility contract, retailers specify only the range within which they will purchase, well before actual demand arises. If demand at various retailers is independent, the supplier does not need to plan production to the high end of the order range for each retailer. It can aggregate uncertainty across all retailers and build a lower level of surplus inventory than would be needed if inventory were disaggregated at each retailer. Retailers then order closer to the point of sale, when demand

is more visible and less uncertain. The aggregation of uncertainty results in less information distortion with a quantity flexibility contract.

As with the other contracts discussed, quantity flexibility contracts result in lower retailer effort. In fact, any contract that gets retailers to provide a higher level of product availability by not making them fully responsible for overstocking will result in a lowering of retailer effort for a given level of inventory.

### Key Point

Risk sharing in a supply chain increases profits for both the supplier and the retailer. Risk sharing mechanisms include buybacks, revenue sharing, and quantity flexibility. Quantity flexibility contracts result in lower information distortion than buyback or revenue-sharing contracts when a supplier sells to multiple buyers or the supplier has excess, flexible capacity.

## Sharing Rewards to Improve Performance

Having discussed the benefits of sharing risk, we now focus on the importance of sharing rewards in a supply chain. In many instances, a buyer wants performance improvement from a supplier that has little incentive to do so. A supplier may be reluctant to invest in improvement if the effort for improvement must be exerted by the supplier but most of the benefits from improvement accrue to the buyer. In such a setting, sharing the benefits from improvement can encourage supplier cooperation, resulting in a better supply chain outcome.

As an example, consider a buyer that wants the supplier to improve performance by reducing lead time for a seasonal item. This is an important component of all quick response initiatives in a supply chain. With a shorter lead time, the buyer hopes to have better forecasts and be better able to match supply and demand. Most of the work to reduce lead time must be done by the supplier, whereas most of the benefit accrues to the buyer in terms of reduced inventories, overstocking, and lost sales. In fact, the supplier will lose sales because the buyer will now carry less safety inventory as a result of shorter lead times and better forecasts. To induce the supplier to reduce lead time, the buyer can use a *shared-savings contract*, with the supplier getting a fraction of the savings that result from reducing lead time. As long as the supplier's share of the savings compensates for any effort it has to put in, its incentive will be aligned with that of the buyer, resulting in an outcome that benefits both parties.

A similar issue arises when a buyer wants to encourage the supplier to improve quality. Improving supply quality reduces the buyer's costs but requires additional effort from the supplier. Once again, a shared-savings contract is a good way to align incentives between the buyer and supplier. The buyer can share savings from improved quality with the supplier. This will encourage the supplier to improve quality to a higher level than what the supplier would choose in the absence of the shared savings.

Another example arises in the context of toxic chemicals that may be used by a manufacturer. The manufacturer would like to decrease the use of these toxic chemicals. Generally, the supplier is better equipped to identify ways of reducing use of these chemicals, because this is its core business. It has no incentive to work with the buyer on reducing use of these chemicals, however, because that will reduce the supplier's sales. A shared-savings contract can be used to align incentives between the supplier and the manufacturer. If the manufacturer shares the savings that result from a reduction in the use of toxic chemicals with the supplier, the supplier will make the effort to reduce use of the chemicals as long as its share of the savings compensates for the loss in margin from reduced sales.

In general, sharing the savings is effective in aligning supplier and buyer incentives when the supplier is required to improve performance along a particular dimension and most of the benefits of improvement accrue to the buyer. A powerful buyer may couple shared savings with penalties for a lack of improvement to further encourage the supplier to improve performance. Sharing the rewards of improvements increases profits for both the buyer and the supplier while achieving outcomes that are beneficial to the supply chain.

### Key Point

Sharing the rewards from improvements can induce performance improvement from a supplier along dimensions, such as lead time, for which the benefit of improvement accrues primarily to the buyer but the effort for improvement comes primarily from the supplier.

## 15.7 THE IMPACT OF INCENTIVES WHEN OUTSOURCING

As companies have outsourced more supply chain activities, it has become harder to align the goals of all parties involved. The misalignment of incentives often hurts supply chain performance. The \$2.5 billion writedown of inventory by Cisco in 2001 is an example of the cost of misaligned incentives. Cisco outsourced production to contract manufacturers and rewarded them for rapid deliveries. The suppliers stockpiled semifinished products for Cisco because the availability of this inventory allowed suppliers to react quickly during an extended period when demand had exceeded supply. When demand slowed in 2000, it took a while before the inflow of components could be curtailed. A reward for rapid deliveries without any negative consequence for inventories led suppliers to build \$2.5 billion of inventory, which became useless when demand slowed. This example is a cautionary tale of the importance of understanding the impact of incentives in a supply chain. Understanding the impact of incentives is important whenever the third party's actions are not fully observable or when the third party has information that is not available to the firm. In either case, it is difficult to design incentives that induce the third party to do what is right for the supply chain.

A good example of the lack of visibility of the third party's actions arises in the automotive supply chain. Consider the case in which Chrysler sells cars through a dealer. The dealer is an agent acting on behalf of the auto company, which is referred to as the principal. The dealer also sells other brands and used cars. Every month, the dealer allocates its sales effort (e.g., sales people, promotions) across all types of cars it sells. Earnings for Chrysler are based on sales of its brands, which in turn are affected by the effort exerted by the dealer. The challenge in this setting is that although Chrysler can observe sales directly, dealer effort is hard to observe and measure. Thus, when sales are high in a given month, it is difficult for Chrysler to infer whether the increase resulted from better market conditions or greater sales effort. In general, Chrysler would like to encourage greater effort from its dealers.

It is well known that incentives offered by the principal can encourage greater effort from the agent. Well-designed incentives can be strong communicators of desired performance. Poorly designed incentives, however, can backfire and hurt supply chain performance. A commonly used performance incentive sets "thresholds" for minimum performance below which there are no rewards. Chrysler offered such an incentive to its dealers in the first quarter of 2001. The rough structure of the incentive was as follows: Dealers would keep the margin made from customers if sales for the month were less than 75 percent of an agreed-upon target. However, if sales reached or exceeded 75 percent but were less than 100 percent of the target, the dealer would get an additional \$150 per car sold. If sales reached or exceeded 100 percent but were less than 110 percent, the dealer would get an additional \$250 per car sold. If sales reached or exceeded 110 percent of the target, the dealer would get an additional \$500 per car sold. Chrysler's hope was that by increasing the margin for higher thresholds, the dealer would have an incentive to increase effort on sales of Chrysler cars.

In the first month after the new contract was announced, the U.S. car industry saw a decrease in sales. Chrysler, however, saw sales drop by twice the industry average. There are three potential causes for this behavior, all related to the structure of the incentive. First, the target set may have been too high. Given that the target was not achievable, dealers decided to suppress effort. Second, under the incentive, the dealer makes more money selling 900 cars one month and 1,100 the next month compared with selling 1,000 cars each month. The dealer has an incentive to shift demand over time to achieve such an outcome, thus increasing information distortion and observed demand variation. The third cause is that within the first week of the

month, the dealer has an idea of the threshold range it is likely to reach. For example, if the dealer believes that it can easily cross the 75 percent threshold but has little chance of crossing the 100 percent threshold, it will decrease its effort for the month and save it for later, because the marginal benefit of selling an additional car is only \$150. In contrast, if demand for the month is high and the dealer believes it can easily cross the 100 percent threshold, it is likely to exert additional effort to reach the 110 percent threshold because the marginal benefit from reaching that threshold is high. Thus, Chrysler's incentive increases variation in dealer effort, further exaggerating any existing market variation.

The following approaches can help dampen the distortion introduced by threshold incentives such as Chrysler's. It is important to ensure that the target set is not too high or too low because the dealer reduces the effort exerted in either case. Even when the target is set fairly, a problem arises if the target is a fixed number that does not vary with market conditions. A reasonable target may become too easy if the market is strong and too difficult if the market is weak. It is better to set a target that adjusts based on market conditions. The challenge, however, is to identify market conditions. One approach used is to adjust the target after sales are observed, based on average sales across all dealers. Thus, when the auto market was down by 8 percent (industry sales are a good measure of market conditions), Chrysler could have lowered the target for its dealers by the same amount. Assuming the original target was fairly set and the dealers were aware of the planned adjustment of the target based on market conditions, they would have continued to exert steady effort. Threshold incentives for which the target is adjusted based on market conditions are more likely to result in steady effort from the third party.

Information distortion is also observed in threshold incentives offered by companies to their sales staff. Under these incentives, staff is offered rewards for crossing sales thresholds during a specified period of time (e.g., a quarter). The problem observed is that sales effort and orders peak during the last few weeks of the quarter, as salespeople try to cross the threshold. This pattern, in which sales peak close to the end of the evaluation period, is referred to as the *hockey stick phenomenon*. This information distortion arises because the incentive is offered over a fixed time period, making the last few weeks of each quarter a period of intense activity for all sales staff.

One approach that firms can take to address the hockey stick phenomenon is to offer threshold incentives over a rolling horizon. For example, if a firm offers its sales staff weekly incentives based on sales over the past 13 weeks, each week becomes the last week of a 13-week period. Sales effort thus becomes more even compared with when the entire sales staff has the same last week for their bonus evaluation. Given the presence of enterprise resource planning (ERP) systems, implementing a rolling horizon incentive is much easier today than it once was. Another approach to address this issue is to recognize that although higher sales benefit supply chain performance, higher variation of sales hurts performance. Incentives can then be designed to reward total sales over a given time period while punishing variation of sales. Even though designing incentives that account for multiple dimensions of performance is difficult, it is important if the goals of the third party and the firm are to be aligned.

### Key Point

Supply chain incentives can have unintended consequences when the third party's information and actions are hard to observe. It is important to understand and address the negative consequences of these incentives.

## 15.8 DESIGNING A SOURCING PORTFOLIO: TAILORED SOURCING

When structuring a supplier portfolio, firms have many options regarding whom to source from and where to source from. With regard to the "whom," a company must decide on whether to produce in-house or outsource to a third party. The company must also decide whether the supply source will be cost efficient or responsive. With regard to the "where," a company can choose among onshoring, near-shoring, and offshoring. *Onshoring* refers to producing the product in the market where it is sold, even when it is a high-cost location. *Near-shoring* refers to producing the

product at a lower-cost location near the market. For the U.S. market, for example, producing in Mexico is near-shoring. For the market in Europe, producing in Eastern Europe is near-shoring. *Offshoring* refers to producing the product at a low-cost location that may be far from the market. In this section, we discuss a variety of factors that influence the design of the sourcing portfolio.

Most companies need to tailor their supplier portfolio based on a variety of product and market characteristics. For example, Zara uses responsive sources out of Europe to produce trendy products that must be in stores quickly to meet customer demand. In contrast, basics such as white T-shirts are sourced out of lower-cost facilities in Asia. Table 15-6 identifies factors that favor the selection of a responsive or low-cost source.

As with Zara, a tailored portfolio consists of a combination of responsive and low-cost suppliers. To use a tailored portfolio effectively, demand should be allocated among suppliers in a way that is consistent with their capabilities. Low-cost suppliers should be given large, steady orders of mature, low-value products that do not require significant engineering or design support. Responsive suppliers, in contrast, should be responsible for high-value, volatile products that are often early in their life cycle and need significant engineering/design support.

In general, responsive sources will tend to be located onshore or near-shore to facilitate a quick response. Low-cost sources could be located anywhere, but low cost is often the main reason for going offshore or near-shore. In Table 15-7, we identify some factors that influence the sourcing location decision.

Large, bulky items such as washing machines and refrigerators are best onshored or near-shored because they have high transportation costs relative to value. In contrast, small items like consumer electronics, especially those that sell in large amounts (say, the iPad), can be offshored. As transportation costs increase, the onshore and near-shore options become more attractive relative to offshoring. For instance, high-value routers with high demand volatility, high inventory costs, and the need for significant management support are outsourced by Cisco to an onshore supplier. Low-value routers with stable designs and low demand volatility, in contrast, are offshored to low-cost countries. As these examples illustrate, it is important for a firm to plan

**TABLE 15-6** Factors Favoring Selection of a Responsive or Low-Cost Source

	Responsive Source	Low-Cost Source
Product life cycle	Early phase	Mature phase
Demand volatility	High	Low
Demand volume	Low	High
Product value	High	Low
Rate of product obsolescence	High	Low
Desired quality	High	Low to medium
Engineering/design support	High	Low

**TABLE 15-7** Factors Favoring Onshoring, Near-Shoring, or Offshoring

	Onshore	Near-Shore	Offshore
Rate of innovation/product variety	High	Medium to High	Low
Demand volatility	High	Medium to High	Low
Labor content	Low	Medium to High	High
Volume or weight-to-value ratio	High	High	Low
Impact of supply chain disruption	High	Medium to High	Low
Inventory costs	High	Medium to High	Low
Engineering/management support	High	High	Low

a tailored sourcing strategy in which the product and market characteristics match with the responsiveness and location of the source.

China and other parts of Asia were popular offshore sources for the two decades between 1990 and 2010. Some trends currently in place, however, are making American managers rethink their offshoring choices. One is the change in Chinese wages and the strengthening yuan, both of which diminish the labor cost advantage of China, especially when compared to near-shore locations such as Mexico. The other is the increase in oil prices and transportation costs that acts as a tariff barrier, making offshoring somewhat less attractive. Finally, the increase in volatility and the need to mitigate risk have also encouraged supply chain designers to include an onshore or near-shore source to complement a low-cost offshore source.

### Key Point

Firms must consider a tailored sourcing strategy that couples responsive onshore or near-shore sources with low-cost offshore sources. The responsive onshore sources should focus on high-value products with high demand volatility, whereas the low-cost, offshore sources should focus on lower-value, high-volume products with high labor content.

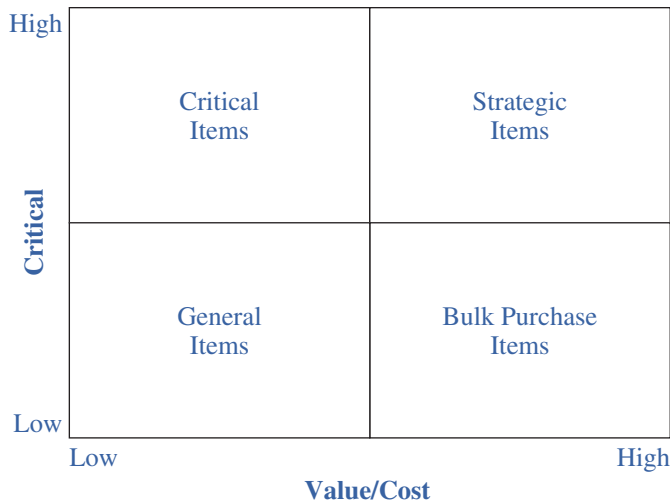
The tailoring of the supplier portfolio should also account for other characteristics of the product being sourced. A simple categorization of purchased goods is into direct and indirect materials. *Direct materials* are components used to make finished goods. For example, the processor is a direct material for a smartphone manufacturer. *Indirect materials* are goods used to support the operations of a firm. Office supplies are examples of indirect materials for an automotive manufacturer. Important differences between direct and indirect materials are shown in Table 15-8.

Given the direct link to production, suppliers for direct materials should be selected based on their ability to collaborate and coordinate across the supply chain. Collaboration is important at both the design and production phases. Collaboration during design can help reduce component costs, whereas collaboration during production can help improve coordination of the supply chain through improved planning and visibility. A good example of collaboration is the relationship between Johnson Controls and Chrysler for the 2002 Jeep Liberty. Johnson Controls integrated components from thirty-five suppliers and delivered the assembly to Chrysler as a cockpit module. As soon as Chrysler notified it of an order for a Jeep, Johnson Controls had 204 minutes in which to build and deliver the module. This was done 900 times every day for about 200 color and interior combinations. The strong collaboration between the two companies resulted in a significant reduction in inventory and a better matching of product supply with end customer demand.

Indirect materials are often a small fraction of the money spent by a firm but can represent a big headache for the procurement department. The purchase of indirect materials typically involves many transactions, with each transaction being small. Each transaction can be costly

**TABLE 15-8** Differences Between Direct and Indirect Materials

	Direct Materials	Indirect Materials
Use	Production	Maintenance, repair, and support operations
Accounting	Cost of goods sold	Selling, general, and administrative (SG&A) expenses
Impact on production	Any delay will delay production	Less direct impact
Processing cost relative to value of transaction	Low	High
Number of transactions	Low	High



**FIGURE 15-1** Product Categorization by Value and Criticality

because of the difficulty of selecting goods (from many catalogs, which are often out of date), getting approval, and creating and sending a purchase order. Suppliers for indirect material should thus be selected based on their ability to simplify each transaction. As suppliers of maintenance and repair parts (typical indirect materials), McMaster-Carr and W.W. Grainger have worked hard to make it easy for their customers to transact with them.

In addition to the categorization of materials into direct and indirect, all products purchased may also be categorized as shown in Figure 15-1, based on their value/cost and how critical they are. Most indirect materials are included in general items. Direct materials can be further classified into bulk purchase, critical, and strategic items. For most bulk purchase items, such as packaging materials and bulk chemicals, suppliers tend to have the same selling price. It is thus important to make a distinction between suppliers based on the services they provide and their performance along all dimensions that affect the total cost of ownership. Critical items include specialty chemicals and components with long lead times. The key sourcing objective for critical items is not low price, but ensuring availability. The presence of a responsive, even if high-cost, supply source can be valuable for critical items. The last category, strategic items, includes examples such as electronics for an auto manufacturer. For strategic items, the buyer–supplier relationship is long term. Thus, suppliers should be evaluated based on the lifetime cost/value of the relationship. The goal should be to identify suppliers that can collaborate in the design phase and coordinate design and production activities with other players in the supply chain.

## 15.9 MAKING SOURCING DECISIONS IN PRACTICE

**1. Use multifunctional teams.** Effective strategies for sourcing result from multifunctional collaboration within the firm. A sourcing strategy from the purchasing group is likely to be relatively narrow and focus on purchase price. A strategy developed with the collaboration of purchasing, manufacturing, engineering, and planning is much more likely to identify the correct drivers of total cost. The collaboration must be continued beyond strategy formulation to the procurement phase, because that is where manufacturing and engineering are most likely to realize the full benefits of good sourcing strategy.

**2. Ensure appropriate coordination across regions and business units.** Coordination of purchasing across all regions and business units allows a firm to maximize economies of scale in purchasing and also to reduce transaction costs. Other opportunities from improved sourcing, such as better supply chain coordination and design collaboration, however, may require strong involvement at the business-unit level to be effective. Mandating global coordination across all

business units may complicate these efforts. Items such as MRO supplies, for which transaction costs and total purchase volume have a significant impact on total cost, benefit most from coordinated purchasing across geography and business units. On the other hand, items for which most of the value is extracted from better design collaboration and coordinated supply chain forecasting and fulfillment are better served with somewhat more decentralized sourcing.

**3. Always evaluate the total cost of ownership.** An effective sourcing strategy should not make price reduction its sole objective. All factors that influence the total cost of ownership should be identified and used in selecting suppliers. Supplier performance along all relevant dimensions should be measured, and its impact on total cost should be quantified. Focusing on the total cost of ownership also allows a buyer to better identify opportunities for better collaboration in design, planning, and fulfillment.

**4. Build long-term relationships with key suppliers.** A basic principle of good sourcing is that a buyer and supplier working together can generate more opportunities for savings than the two parties working independently. Solid cooperation is likely to result only when the two parties have a long-term relationship and a degree of trust. A long-term relationship encourages the supplier to expend greater effort on issues that are important to a particular buyer. This includes investment in buyer-specific technology and design collaboration. A long-term relationship also improves communication and coordination between the two parties. These capabilities are very important when sourcing direct materials. Thus, long-term relationships should be nurtured with suppliers of critical and strategic direct materials.

### Sourcing Solutions—An Indian Example

As an example of internal sourcing, we can look at eKart, the logistics wing of Flipkart. With the parent company bearing the logistics costs and exercising control over operations of its logistics wing, it has ensured high degree of on-time delivery at lower costs. Of late, Ekart Logistic (EKL), has started providing its logistics services to other ecommerce companies and e-tailers and is now emerging as a full-fledged 3 PL service.

Yet in a country of sub-continental size, EKL does not have its reach in all parts. In such cases, Flipkart relies on other courier companies and Indian Postal Services, judiciously dividing loads between EKL and other 3 PL service providers depending up the locations to be served and the quantum of load, thus ensuring timely delivery of all orders.

## 15.10 SUMMARY OF LEARNING OBJECTIVES

**1. Understand the role of sourcing in a supply chain.** Sourcing encompasses all processes required for a firm to purchase goods from suppliers. Over the past two decades, manufacturing firms have increased the fraction of purchased parts. Effective sourcing decisions thus have a significant impact on financial performance. Good sourcing decisions focus on the total cost of ownership and aim to identify suppliers that will grow the supply chain surplus.

**2. Discuss factors that affect the decision to outsource a supply chain function.** A supply chain function should be outsourced if the third party can increase the supply chain surplus without significant risk. A third party may increase the surplus by aggregating capacity, inventory, warehousing, transportation, information, receivables, and other factors to a higher level than the firm can on its own. Outsourcing generally makes sense if a firm's needs are small and highly uncertain and can be served using resources that can serve other firms as well. Outsourcing also makes sense if the firm is short of capital or if the third party has a lower cost of capital.

**3. Identify dimensions of supplier performance that affect total cost.** Total cost includes the cost of acquisition, ownership, and post-ownership. In addition to the supplier price, the total cost of using a supplier is affected by the supplier terms; delivery costs; inventory costs; warehousing costs; quality costs; costs of management effort and administrative support; impact on reputation; supplier capabilities, such as replenishment lead time, on-time performance, and flexibility; and other costs, such as exchange rate trends, taxes, and duties.