CHAPTER

17

Sustainability and the Supply Chain

LEARNING OBJECTIVES

After reading this chapter, you will be able to

1. Understand the importance of sustainability in a supply chain.
2. Discuss the challenge to sustainability posed by the tragedy of the commons.
3. Describe key dimensions of sustainability for a supply chain.
4. Understand the role of incentives for successful sustainability efforts.

Sustainability has become a key priority in the design and operation of supply chains in the twenty-first century. A focus on sustainability allows a supply chain to better serve more environmentally conscious customers while often improving supply chain performance. In this chapter, we explore the importance of sustainability, some challenges to designing and operating more sustainable supply chains, and the role of different supply chain drivers in improving sustainability.

17.1 THE ROLE OF SUSTAINABILITY IN A SUPPLY CHAIN

This book has focused on designing and operating supply chains with a goal of growing the supply chain surplus. Each supply chain, however, is only a small part of the world in which it resides. Ultimately, the health and survival of every supply chain and every individual depend on the health of the surrounding world. It is thus important to expand the goal of a supply chain beyond the interests of its participants (which the supply chain surplus represents) to others that may be affected by supply chain decisions. It is in this context that the twenty-first century has seen a growing focus on sustainability. The Brundtland Commission of the United Nations defined *sustainable development* as "development that meets the needs of the present without compromising the ability of future generations to meet their own needs." The 2005 World Summit of the United Nations introduced a framework identifying economic, environmental, and social sustainability as the "three pillars" of sustainable development. All three pillars must be reconciled for sustainability to occur.

The focus on sustainability has increased as the economies in large countries such as Brazil, China, and India have grown. On the one hand, the growth of emerging markets is improving global living standards in a way that perhaps has not happened before in human history. On the other hand, this growth puts pressure on resources and the environment in a way that has also never happened. It has become increasingly clear that if supply chains do not become more sustainable than they have been in the past, the world's resources and environment will not be able to maintain this level of growth.

The factors driving an increased focus on supply chain sustainability can be divided into three distinct categories:

1. Reducing risk and improving the financial performance of the supply chain
2. Community pressures and government mandates
3. Attracting customers that value sustainability

Even though there has been a great deal of talk about all three categories, most concrete action has been observed in reducing risk for the supply chain and improving financial performance. The early part of the twenty-first century has seen an increase in community pressure and government mandates in some parts of the world. Much less success has been driven by customer demand or a firm desire to make the world more sustainable. It is interesting to note that significant opportunity exists even if supply chains focus only on reducing risk and improving financial performance. A McKinsey report (Creyts et al., 2007) focusing on greenhouse gas emissions reported, "Almost 40 percent of [greenhouse gas] abatement could be achieved at negative marginal costs, meaning that investing in these options would generate positive economic returns over their lifecycle." Despite the existence of financially viable opportunities to increase sustainability, activity has been slow because many of these actions require upfront investment that pays off in the long term. An example is the investment in light-emitting diode (LED) lighting by Walmart. Even though it has required upfront investment, installing LED lights has significantly reduced energy consumption at Walmart stores. Despite the long-term payoff, though, few other firms have followed Walmart because of the large upfront investment.

Although much still needs to be done, many companies have reported success in improving sustainability. Unilever, the Dutch–British consumer goods giant, has invested significant effort to help emerging economies such as Brazil and India wrestle with poverty, water scarcity, and climate change. In Brazil, the company helped tomato growers convert to drip irrigation to save water. The company sees almost half of its sales and the majority of its growth coming from emerging economies. It buys roughly "10 percent of the world's crops of tea and 30 percent of all spinach."[1] A focus on sustainability helps Unilever improve the environment and economic health of markets where it is likely to see most of its future growth, while simultaneously ensuring supply of products it needs to feed this growth.

Walmart started its focus on sustainability as a defensive move, given the criticism it was receiving from environmental activists. The company, however, has seen many benefits to its bottom line. Switching to more efficient light bulbs at its stores and adding skylights for natural light have helped significantly reduce its energy costs. Reducing packaging has helped reduce material costs and transportation costs. Another example is the redesign of the one-gallon milk jug by Walmart and Costco to use less material and increase packing density during transportation. Even though it took the public some time to accept the new design, the effort saved "10 to 20 cents a gallon compared to old jugs."[2]

Starbucks is another example of a company that has focused on sustainability for significant business reasons. In the late 1990s, the company realized that its growth plans could not be

[1]"Beyond the Green Corporation," *Business Week*, January 29, 2007.
[2]"Solution, or Mess? A Milk Jug for a Green Earth," *New York Times*, June 30, 2008.

sustained without helping coffee growers increase their production in a sustainable manner. The company thus started its coffee and farmer equity (C.A.F.E.) practices, which evaluate the sustainable production of coffee along four dimensions: product quality, economic accountability, social responsibility, and environmental leadership. According to the company, "the first two categories are prerequisites to participation in the program and ensure basic coffee quality and financial transparency, equity, and the viability of the coffee supply chain." Social responsibility measures the extent to which the working conditions are safe and humane. Environmental leadership measures the actions that suppliers are taking to "manage waste, protect water quality, conserve water and energy, preserve biodiversity and reduce agrochemical use." Applicants are given "preferred supplier" status based on the score they achieve across the four categories. Preferred suppliers get a pricing premium of $0.05 per pound along with favorable contract terms. The company claims that it sourced 95 percent of its coffee in 2013 from sources that were "third-party verified or certified through C.A.F.E. practices, Fairtrade or another externally audited system." Besides helping attract customers who care about sustainability, these efforts have helped Starbucks reduce supply risk and ensure an ongoing supply of high-quality coffee, the most critical input for its business.

Sustainability has presented more of a challenge when it requires efforts that do not provide obvious return on investment for a company. In fact, customers themselves have not always backed up their words about the importance of sustainability with a willingness to pay more for sustainable products or make more of an effort to support sustainability. As an example, Starbucks has been able to increase the percentage of beverages served in customer-owned tumblers from 1.4 percent in 2009 only to 1.8 percent in 2013. Of all the dimensions the company reported in its 2013 Global Responsibility Report, this was the dimension that saw the smallest improvement. In a survey, business leaders identified insufficient return on investment, customers' unwillingness to pay a premium for green products, and difficulty evaluating sustainability across a product life cycle as the major barriers to an increased focus on sustainability.[3] When the business rationale for an increased focus on sustainability is not clearly defined for individual firms, maintaining the focus needed for building more sustainable supply chains is much harder. As we discuss in the next section, one of the biggest challenges to building sustainable supply chains is that in the short to medium term, an improved focus on sustainability provides benefits that are shared but costs that may be local to a firm or individual, whereas the current status quo provides benefits that are local to firms or individuals but a cost that is global.

17.2 THE TRAGEDY OF THE COMMONS

In an influential article, Hardin (1968) described the *tragedy of the commons* as a dilemma arising when the common good does not align perfectly with the good of individual entities. It is useful to study his example in somewhat greater detail. Consider a pasture that is open to all herders with cattle. Each herder attempts to maximize his gain from this public asset. When one herder's cattle feed in the pasture, that herder gains from their growth and all the gains accrue only to him. Any cost of overgrazing, however, is spread over all herders whose cattle feed at the pasture. Thus, overgrazing by the cattle of any herder provides a positive utility of +1 for that herder but a negative utility of only a fraction of –1 for the herder because the negative utility of –1 is spread over all herders. Thus, each rational herder continues to increase his herd because the positive utility to that herder of adding another animal exceeds the negative utility that he experiences from overgrazing. As Hardin writes, "Therein is the tragedy. Each man is locked into a system that compels him to increase his herd without limit—in a world that is limited. Ruin is the destination toward which all men rush, each pursuing his own best interest in a society that believes in the freedom of the commons. Freedom in a commons brings ruin to all."

[3]Gibbs & Soell survey, accessed May 1, 2011, www.cnbc.com/id/42432191/

Hardin then describes how the issue of environmental pollution is essentially the tragedy of the commons. Every individual and every company releases waste and pollution into the environment in the form of sewage, chemicals, and carbon dioxide. The individual or the company would incur the entire cost of reducing the amount of waste it discards, whereas the cost of throwing waste into the environment is shared by the entire world. The common environment available to all at no cost makes it difficult to get every company to invest in waste reduction efforts, even though this waste hurts everybody.

This issue also appears at the country level. The Intergovernmental Panel on Climate Change, a United Nations body that has been assessing global warming since 1990, has written that even though most of the buildup of carbon dioxide in the atmosphere has come from the United States and Western Europe, poorer countries closer to the equator are likely to pay the biggest price. The risk of drought, disrupted water supplies, and the swelling of oceans from melting ice sheets as a result of global warming will be experienced mostly in Africa and the "crowded river deltas in southern Asia and Egypt, along with small island nations."[4] In such an environment, getting any agreement on action is difficult because the optimal joint action is not individually optimal, whether at the company or country level. No wonder that it has been almost impossible to negotiate a climate change agreement that every country is willing to adhere to! Other examples of the tragedy of the commons come from the overuse of natural resources such as fish, water, and forests. Overfishing of sturgeon in Russia and the destruction of salmon runs in rivers that have been dammed are well documented.

Every company and supply chain faces the challenge of the tragedy of the commons as it operates in a global environment. They must compete against others that may be extracting benefits from the environmental or resource commons without spending to maintain these commons. They must compete in a market in which customers often value low cost and are not willing to pay the price of a more sustainable solution, in the form of either a higher price or reduced consumption. Unless all consumers suddenly change their mindsets, it is difficult to imagine a sustainable solution emerging without some intervention. Whereas everyone agrees about the need for intervention, there is considerable disagreement on the required form of intervention.

What Are Some Solutions to This "Tragedy"?

In his article, Hardin focused on the problem arising from the fact that the commons are "free" to all. As he put it, no solution could be found without taking away some of the freedom that participants enjoyed in the commons. Regarding the national parks in the United States, he wrote, "We might sell them off as private property. We might keep them as public property, but allocate the right to enter them. The allocation might be on the basis of wealth, by the use of an auction system. It might be on the basis of merit, as defined by some agreed upon standards. It might be by lottery. Or it might be on a first-come, first-served basis, administered to long queues. These, I think, are all objectionable. But we must choose—or acquiesce in the destruction of the commons that we call our National Parks." Rather than focus on Hardin's many ideas, it is important to understand his point—the need for us to choose from options that are unlikely to be supported by all of their own free will.

In the article, Hardin introduces the idea of "mutual coercion," whereby social arrangements or mechanisms coerce all participants to behave in a way that helps the common good. Given that participants will not tend to the commons of their own free will, mutual coercion mechanisms that apply to all participants can encourage the appropriate behavior. Mutual coercion can be attempted through a command-and-control approach or market mechanisms. We introduce these approaches in this section but discuss them in greater detail in Section 17.6. As with Hardin's suggestions for the national parks, both command-and-control and market mechanisms have some aspects that are "objectionable." Despite the absence of a perfect solution, it is important to make a choice. Otherwise the environmental commons will continue to degrade.

[4]Andrew C. Revkin, "Poor Nations to Bear Brunt as World Warms." *New York Times*, April 1, 2007.

In a command-and-control approach, the government or regulators set standards that everybody must adhere to. An example is carbon monoxide emission standards set by the United States for new automobiles. Another example is the Waste Electrical and Electronic Equipment (WEEE) Directive from the European Union that is geared at proper recycling and landfill avoidance in the electrical and electronics industry. A third example is the use of higher fuel efficiency standards for the automobile industry. These standards increase the required fuel efficiency from about 29 miles per gallon in 2012 to 54.5 miles per gallon in 2025. The challenge with command-and-control approaches is that they tend to be inflexible and are not always cost effective. An example is the Environmental Protection Agency proposal to require carbon capture technologies at new coal-fired power plants. Besides increasing overall electricity costs, there is fear that this proposal is unlikely to be effective because of the high cost of carbon capture technology. The high cost of the mandate may push power plant operators away from coal-fired plants, which may slow down research in carbon capture and hurt future improvements in the area. Rather than improve performance in carbon capture, such a mandate may slow down future innovation in this space.

We give a couple of examples of market mechanisms that have been debated (but not yet implemented nationally in the United States as of October 2014) in the context of greenhouse gases, a problem that is only getting worse as supply chains become more global. Currently, there is no "charge" for emitting greenhouse gases and no explicit limits that are strictly enforced. The commons here is the environment, and the lack of any "mutual coercion" leads to excessive emission of greenhouse gases into the atmosphere. The hope is to set mechanisms in place that can sustainably address the problem.

One mechanism, referred to as *cap-and-trade*, constrains the aggregate emissions by creating a limited number of tradable emission allowances that emission sources must secure and surrender in proportion to their emissions. Any failure to surrender the appropriate number of allowances leads to a significant fine. The mechanism starts with the government creating a limited number of total allowances that are distributed among all players in the economy. If players generate fewer emissions than the allowances they own, they can sell their surplus allowances to others that may be polluting above their limit and need additional allowances. The "price" of allowances in this mechanism is created by the supply and demand for allowances. Such a mechanism offers companies an incentive to reduce their emissions because they get a financial reward for this improvement by selling their additional allowances to those that cannot (or are unable to) reduce their emissions. The hope with this mechanism is that firms will choose the least expensive way to comply with the emissions limit by either implementing emissions reduction plans or buying allowances on the open market. This mechanism has been implemented by several regions, including the European Union (EU) and the state of California. The experience of the EU points to one of the challenges of implementing cap-and-trade. The Emissions Trading Scheme (ETS) was launched by the EU in 2005 with a distribution of free permits or allowances. Once trading started, the price of these allowances peaked around 30 euro a ton in April 2006 before collapsing to below 5 euro a ton by 2013. The drop in price took away any incentive for firms to make further improvements in emissions. This failure of the market was linked to the distribution of too many free allowances and the setting of caps that were easily reached using the improvements made by firms. California, which started its cap-and-trade program in 2013, distributed a fraction of the permits free and has auctioned off the rest. California has also established a floor on the price of these permits during the auctions. The use of auctions with a floor price to release permits has allowed for a better equilibrium that is less likely to collapse. The EU has also changed its plans and moved from free allocations to auctions as the method for allocating allowances. The Acid Rain Program is another market-based initiative by the U.S. Environmental Protection Agency that has had success in reducing overall levels of sulfur dioxide and nitrogen oxides in the atmosphere.

A second mechanism to control emissions is an emission tax. Each entity generating greenhouse gases is charged a tax proportional to the size of the emissions. This is similar in principle to the congestion-based toll we discussed to manage traffic congestion (see Chapter 14). A charge for emissions encourages companies to reduce their emissions using all ideas whose marginal cost is less than the charge. As a result of an emission tax, the total amount of greenhouse gases produced will decrease. These taxes are often implemented on fossil fuels related to carbon content. For example, India introduced a nationwide carbon tax of 50 rupees per metric ton of coal both produced and imported into India.[5] Similarly, Japan has introduced a tax on oil, natural gas, and coal that is expected to cost utilities about 80 billion yen annually from 2016.[6] One problem with a carbon tax, though, is that it tends to be regressive and hurt low-income groups to a greater extent.

We discuss the pros and cons of cap-and-trade versus a carbon tax in greater detail in Section 17.6. There is still considerable debate among experts about the relative merits of the two approaches. Unfortunately, this debate has slowed the implementation of either approach across the globe. The challenge of tending the environmental commons is magnified because the state of the environment is affected by every region of the world. To be effective, mutual coercion must have the same global reach as the environment. Solutions are unlikely to be effective unless there is global coordination in the implementation of any mutual coercion mechanisms. The need for coordination is evident even in the experience of the EU with cap-and-trade. After starting with national caps that created problems, the EU had to shift to EU-wide caps. There is concern that the introduction of cap-and-trade in California may result in some firms moving out of the state. In the absence of global coordination, it will be difficult to get market mechanisms to be very effective in controlling emissions. The need for global coordination is particularly important given that although most of the existing emissions have come from the developed world, an increasing share of future emissions is likely to come from economies that are still developing. It will not be enough to have solutions that are limited to the developed world.

17.3 KEY PILLARS OF SUSTAINABILITY

Sustainability in a supply chain can be viewed along three pillars—social, environmental, and economic. Major global corporations such as Walmart and Starbucks report their economic performance in their annual reports and their social and environmental performance in their global responsibility reports (also called corporate social responsibility reports). As we mentioned earlier, many actions taken in a supply chain can improve performance in all three dimensions. For example, the use of modular design by IKEA allows the company to tightly pack its parts when they are shipped from the production location to its retail stores. Modular design allows the company to simultaneously reduce emissions as well as its transportation costs. SC Johnson, a manufacturer of cleaning supplies and other consumer goods, has reported that between 1990 and 1999 the company used its eco-efficiency efforts to cut more than 420 million pounds of waste and save $125 million. The majority of sustainability-related efforts, however, have a cost that the supply chain incurs for a benefit that may be more universal. In such situations, measuring performance along all three pillars is required to evaluate the impact of sustainability-related efforts in the supply chain.

Two fundamental challenges exist in a supply chain in the measurement and reporting of the social and environmental pillars. The first challenge relates to the scope over which a category is measured. Consider a company that reports only energy consumption within its own operations. If it decides to outsource some production to an offshore supplier, its own energy consumption will show a decline even though the energy consumption in the entire supply chain may have increased. If it decides to bring some production in-house and onshore, the energy consumption within its operations will show an increase even if the energy consumption for the

[5]Krittivas Mukherjee, "India Eyes Millions in Green Funds from Coal Tax," Reuters, February 26, 2010.
[6]Risa Maeda, "Japan's New Carbon Tax to Cost Utilities $1 Billion Annually," Reuters, October 10, 2012.

entire supply chain has decreased. Thus, it is important to clearly define the scope across which all metrics are measured and reported. In the context of greenhouse gas emission, the Greenhouse Gas Protocol (GHG Protocol) initiative[7] defines three scope levels. Scope 1 refers to emissions from GHG sources that are owned or controlled by the reporting entity, also referred to as *direct emissions*. Scope 2 refers to the inclusion of indirect emissions from grid-sourced electricity and other utility services, including heat, steam, and cooling. Scope 3 refers to the inclusion of other indirect emissions coming from the production of purchased materials, outsourced activities, contractor-owned vehicles, waste disposal, and employee business travel. For most firms, the extent of direct emissions is typically only a small fraction of the extent of indirect emissions in the supply chain. For example, a detailed analysis by the pharmaceutical company Abbott indicated that its indirect emissions were about 6 to 14 times its direct emissions. For a typical retailer, only about 7 percent of the environmental impact is direct, with the remaining 93 percent coming from other parts of the supply chain. It is thus crucial to measure the social, environmental, and economic impacts across the entire supply chain.

The second challenge in measurement and reporting relates to the use of absolute or relative measures of performance. An absolute measure reports the total amount of energy consumption, whereas a relative measure may report the energy consumed per unit of output. The advantage of using an absolute measure is that it reports the full impact of the supply chain (assuming we use scope 3) along the category being measured. The disadvantage is that a drop in supply chain sales and production will show a lower absolute measure of energy consumption even though the company may not have improved anything. This was the case in Europe around 2012, when the economic slowdown resulted in lower emissions even when firms had made no improvements. A relative measure of performance, such as emissions per ton of output, is more effective at capturing improvement. The challenge with using a relative measure is the choice of basic unit because each category can be measured relative to a variety of units, such as dollars of sales, kilograms of output, or square feet of space. In general, it is better for firms to measure and report both absolute and relative measures to get a true picture of their performance.

Next, we elaborate on different dimensions of the social and environmental pillars using Walmart and Starbucks as examples.

Social Pillar

The social pillar measures a firm's ability to address issues that are important for its workforce, customers, and society. Workforce-related factors include employment quality, health and safety, training and development, and diversity and opportunity. Customer-related factors include accurate product information and labeling, along with the impact of the product on the customer's health and safety. Social issues include human rights and the impact on local communities.

In their global responsibility reports, both Walmart and Starbucks report on each of these social factors. Walmart and Starbucks source significant amounts of product from third parties all over the world. Thus, their performance with regards to workforce must include their suppliers. Walmart has focused on issues related to worker safety, women's empowerment, and anti-human trafficking at its suppliers. It has created "Standards for Suppliers" that require suppliers to eliminate forced or child labor, offer wages and labor hours consistent with local law, and look after the health and safety of workers. When third parties are involved, it is not enough to set standards; the company must perform credible audits to ensure that the standards are being followed. Walmart claims to audit each facility every 6 to 24 months. Some audits are performed by the company, but most audits are performed through third-party organizations. The company claims that it performed 11,568 audits in 2012 and that "our suppliers were required to cease production in 214 factories due to serious violations."[8] Similarly, Starbucks claims to have

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[7]Accessed May 2, 2011, from www.ghgprotocol.org
[8]Walmart Global Responsibility Report 2013.

sourced 95 percent of its coffee in 2013 "through C.A.F.E. practices, Fairtrade or another externally audited system."[9] Besides standards and audits, it is important for large firms such as Walmart and Starbucks to provide support to their (often much smaller) suppliers in emerging economies as they move on their journey toward greater sustainability. Simply setting standards followed by audits may not suffice if suppliers do not have the capability to make changes on their own. A 2013 study by the Global Supply Chain Management Forum at Stanford University found that "supplier collaboration and capability building" seem to be "strongly associated with social and environmental responsibility performance improvement and lower operating costs."

The cost of audits and capability building at suppliers are often borne by a firm, whereas the benefits from supplier improvement accrue to all that use the supplier. As discussed in the tragedy of the commons, large firms do not spend sufficient effort on audits and capability building at suppliers because of the absence of effective mechanisms for "mutual coercion." This can be a challenge even with the best of intentions. For example, Western retailers and apparel brands reacted to public outrage resulting from the collapse of the Rana Plaza factory near Dhaka, Bangladesh, in 2013 by starting a major push to improve building safety. Instead of coordinating this effort, however, they formed two distinct groups. One group—the Bangladesh Accord for Fire and Building Safety—included many European brands, such as H&M, Carrefour, and Mango, whereas the other group—the Alliance for Bangladesh Worker Safety—included 26 companies from Canada and the United States. The two groups often clashed, detracting from the overall effort. "Some members of the American-dominated alliance said that their side had performed more inspections than the European-dominated accord, while some accord members asserted that the alliance's inspections were less rigorous."[10] Clearly, the absence of coordinated action hurt outcomes in Bangladesh even though the companies involved may have had the best of intentions.

Environmental Pillar

The environmental pillar measures a firm's impact on the environment, including air, land, water, and ecosystems. Firm activities that improve the environmental pillar can be categorized as resource reduction, emission reduction, and product innovation. Resource reduction activities result in a more efficient use of natural resources in the supply chain. Starbucks' ability to reduce water consumption in company-operated stores by 21 percent between 2008 and 2013 is an example of resource reduction. Emission reduction activities reduce hazardous air emissions (e.g., greenhouse gases), waste, water discharges, or the environmental impact of the company in the community. Walmart's ability to reduce greenhouse gas emissions in its 2005 adjusted base of stores by more than 20 percent is an example of emission reduction. Product innovation reflects a company's ability to reduce the environmental costs and burden for its customers through the development of eco-efficient products or services. The high-efficiency toilet, for example, is a product innovation that allows users to significantly reduce their water discharge.

Resources used by firms include materials, energy, water, and land. Starbucks has reduced water consumption at its North American stores from 24.35 gallons per square foot/month/store in 2008 to 19.22 gallons in 2013 through the use of efficient fixtures and equipment, along with active monitoring of consumption. To reduce its energy consumption, Walmart has focused on its HVAC, refrigeration, and lighting. The installation of LED freezer case lighting by the company followed by the rollout of LED sales floor lighting has allowed the company to reduce energy consumption at its stores. According to its 2013 Global Responsibility Report, Walmart reduced fuel consumption in 2012 and "delivered 297 million more cases while driving 11 million fewer miles." Resource reduction activities not only help the environment, but they also save money for a company. For example, Walmart claimed that the improved fuel and delivery efficiency of its fleet "saved the company and our customers almost $130 million."

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[9] Starbucks Global Responsibility Report 2013.
[10] Steven Greenhouse and Elizabeth A. Harris, "Battling for a Safer Bangladesh," *New York Times*, April 21, 2014.

Emissions from a firm that may harm the environment include greenhouses gases, carbon dioxide, ozone-depleting substances, nitrogen and sulfur oxides, waste, and water discharges. Given that about 80 percent of Starbucks' direct greenhouse gas emissions come from the energy used to power its stores and facilities, the company has focused on building new company-operated stores to the U.S. Green Building Council's Leadership in Energy and Environmental Design (LEED) certification standards. In 2012 and 2013, about 65 percent of the new stores built were LEED certified. Single-use shopping bags are a significant source of waste; retailers have made a concerted effort to get customers to start using multi-use bags. This effort has been fairly successful in most parts of the world where it has been implemented. Walmart claimed to have reduced its plastic shopping bag waste per store by more than 38 percent between 2007 and 2013. Emission reduction activities can be more challenging to implement because they often require upfront investment and changes in behavior from employees and customers.

Although there are several examples of environmentally friendly product innovation, this is also an area in which most claims should be skeptically viewed. According to a study led by marketing consultancy TerraChoice, "more than 98 percent of supposedly natural and environmentally friendly products on U.S. supermarket shelves are making potentially false or misleading claims, and 22 percent of products are making green claims that have no inherent meaning."[11] The term *greenwashing* is often used to refer to products and practices that seem green but fundamentally aim to grow profits.

The Institute for Local Self-Reliance (ILSR) has questioned whether Walmart's claims with regard to environmental responsibility are entirely justified. It points to the fact that Walmart's demands for lower prices from its suppliers has driven down the quality and durability of consumer goods. This has sped up the "flow of goods from factory to landfill, vastly expanding the amount of stuff Americans buy and discard."[12] It also notes that Americans "throw away an average of 83 pounds of textiles per person, mostly discarded apparel, each year." The issues cited by ILSR have some validity and point to the difficulty of assessing claims on environmental responsibility. Should Walmart be held responsible for the things customers throw away? Or should customers bear the responsibility of wanting cheaper products, which may be less durable? It also points to the importance of expanding the scope of analysis to the entire supply chain, from the customer to the last supplier, when evaluating the environmental impact of an action.

When starting on its sustainability improvement journey, it is best for a firm to first focus on resource reduction activities. Whether reducing packaging material, energy use, or transportation, resource reduction activities are most likely to provide a win–win outcome that helps the environment while improving profits. Such successes can provide the momentum for more challenging sustainability activities. The push for resource reduction is likely to be aided by the increase in fuel and shipping costs. As shipping costs grow, supply chain networks are likely to become somewhat more regional, helping reduce emissions from transportation. In the long run, however, the biggest benefits to society are likely to accrue when firms include the social and environmental pillars when making their sourcing decisions. The biggest challenge to social and environmental improvements is likely to be the fact that most of the effort is local to a firm (and maybe its supply chain), whereas the benefits are more widely distributed. The tragedy of the commons and the difficulty of measuring change across the entire scope of the supply chain are likely to make real progress slow while companies continue to claim large improvements related to sustainability.

17.4 SUSTAINABILITY AND SUPPLY CHAIN DRIVERS

Opportunities for improving supply chain sustainability can be identified by matching the social (workforce, customer, society) and environmental (resource reduction, emission reduction, product innovation) pillars we have described with the various supply chain drivers discussed in this

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[11]Erica Orange, "From Eco-Friendly to Eco-Intelligent," *The Futurist*, September–October 2010.
[12]"Top Ten Ways Walmart Fails on Sustainability," Institute for Local Self-Reliance, April 2012.

text. The goal is for every firm to measure its environmental impact for each driver along each of the social and environmental categories. In this section, we discuss some of the opportunities available for each driver and provide some examples.

Facilities

Facilities tend to be significant consumers of energy and water and emitters of waste and greenhouse gases and thus offer significant opportunities for profitable improvement. Once a firm measures the direct impact of each facility in terms of energy, water, emissions, and waste, it should separate the improvement opportunities into those that generate positive cash flows and those that do not. Successful companies start by identifying and implementing the profitable projects first. According to its 2011 Corporate Social Responsibility (CSR) report, Walmart has designed and opened a viable store prototype that is up to 25 to 30 percent more energy efficient and produces up to 30 percent fewer greenhouse gas emissions compared with the 2005 baseline. Using more energy-efficient light bulbs and building skylights for natural light has cut energy consumption at its existing stores. Walmart has also worked to convert waste management at its stores from a cost to a profit generator. The company reported that in 2011 it prevented more than 80 percent of waste generated by its stores and distribution centers from going to landfills. Most of this success came from "working with vendors to eliminate materials from becoming part of the waste or recycling stream in the first place."

Another example of profitable improvement comes from using technology to balance the peak load for energy across a chain of convenience stores. By suitably staggering the time that air conditioners and freezers at its stores are turned on, the chain can reduce the peak demand for energy across the store network, resulting in lower costs for the chain and a reduced demand for peak load in the grid. Several companies are designing the hardware and software necessary to operate such systems. Efforts to reduce peak load are likely to be most successful when utilities include a peak charge, thus rewarding customers that reduce peak consumption.

Production facilities often have significant opportunity to reuse heat energy generated and reduce water usage during the process. Coca-Cola has worked hard to reuse heat energy from boilers in its production process and reduce its total water footprint. Lee (2010) gives the example of Posco, which worked with its equipment supplier, Siemens VAI, to create a new production process that cut costs and emissions without hurting product quality by using local iron ore that was of lower quality but less expensive. As a result, Posco reduced the cost of a new mill by 6 percent to 17 percent and decreased its operating costs by 15 percent while producing lower levels of greenhouse gases and other waste. As these examples illustrate, facilities often offer the best opportunity to simultaneously improve the environmental and financial performances through innovation.

Inventory

Most supply chains focus on raw materials, work in process, and finished goods inventory, as we have done in this text. Although this form of inventory is viewed as an asset and included in the financials, few firms even consider the inventory sitting in a typical landfill. When a firm's product is discarded in a landfill after use, the cost of this inventory is borne collectively by society. Even though the inventory in the landfill may not show up in a firm's balance sheet, it does show up as one of the most damaging aspects from a sustainability perspective. The damage may be in the form of harmful additives or in the form of valuable energy and materials that are still locked in the landfill. Arguably, the most significant waste in any supply chain occurs when a product is thrown into a landfill because both materials and energy used to produce the product are now lost forever, potentially doing harm. The goal of every supply chain should be to track its landfill inventory and separate it in terms of harmful additives and unused value. Life-cycle assessment can be used to assess the environmental impacts associated with a product's life from cradle to grave. The goal should be to reduce (or at least limit) the harmful inventory and unlock the unused value in products when they are discarded. In Section 17.5, we discuss the challenges of designing closed-loop supply chains that reduce landfill inventory through effective recycling or remanufacturing.

McDonough and Braungart (2002) discuss the importance of "cradle to cradle" design if we are to truly limit the landfill inventory generated by a supply chain. They suggest designing products "that, when their useful life is over, do not become useless waste but can be tossed onto the ground to decompose and become food for plants and animals and nutrients for soil; or, alternately, they can return to industrial cycles to supply high quality raw materials for new products." For example, Cyberpac, a British company, has developed several products that seek to replace plastic packaging with compostable equivalents using starch-based resources and hydro-degradable plastic. The Bioplastics Feedstock Alliance, formed by several companies and the World Wildlife Fund, encourages the development of plastics from plant matter.

Transportation

Transportation is another driver with which firms are likely to find several positive cash flow opportunities that improve environmental performance through resource as well as emission reduction. Any supply chain design innovation that lowers transportation costs also tends to reduce fuel consumption, as well as emissions and waste generated from transportation. As fuel costs increase in the future, firms are likely to restructure their products and supply chains to reduce transportation costs. Along with a decrease in transportation costs, these changes (such as near-shoring or onshoring) are also likely to decrease fuel use and emissions. In its 2011 CSR report, Walmart reported that in the United States, it decreased the amount of fuel used to deliver a case of product by 65 percent between 2005 and 2010. This improvement—through increased aggregation, a more efficient loading of transportation vehicles, and an increase in their fuel efficiency—cuts both costs and environmental damage. Lee (2010) cites four companies—Hewlett-Packard, Electrolux, Sony, and Braun—that have formed a joint venture, the European Recycling Platform, to gain better economies of scale in their recycling efforts. Lee reports that HP's cost of recycling digital cameras is only 1 or 2 euro cents in countries with the environmental platform, compared with 7 euro cents to 1.24 euros in countries without the platform. Ocean Spray and Tropicana, with presence in Massachusetts and Florida, respectively, have collaborated to take advantage of empty delivery trucks to backhaul each other's product along the U.S. East Coast, saving both fuel and money.

Product design can also play a significant role in reducing transportation cost and emissions by reducing packaging and allowing greater density during transportation. IKEA has always worked hard to design products that can be shipped flat to achieve high volume and weight density during transportation. As a result, the company not only lowers its transportation costs, but it also reduces emissions and energy use.

Sourcing

For most firms, the greatest social and environmental impact occurs in the extended supply chain outside their own enterprise. This impact has grown as firms have increased their global sourcing, especially from low-cost countries. Thus, to truly have an impact on sustainability, powerful players must look at the extended supply chain and work with their suppliers to improve performance. As we have mentioned earlier, the C.A.F.E. program at Starbucks encourages suppliers to improve their environmental and social responsibility scores by providing a price premium. Walmart and IKEA have also set aggressive targets for their suppliers to improve overall supply chain sustainability. Failure to work with suppliers on sustainability should also be viewed as a potential source of risk that can cause considerable damage to the reputation and sales of a firm. The presence of lead paint in some of its most popular toys, for instance, forced Mattel to recall hundreds of thousands of toys sold between April and July 2007.[13]

[13]Louise Story, "Lead Paint Prompts Mattel to Recall 967,000 Toys." *New York Times*, August 2, 2007.

Verifying and tracking supplier performance with regard to sustainability, however, continues to be a major challenge for most firms. This challenge arises, at least partially, because of the tragedy of the commons. After all, the benefits from improved social and environmental responsibility at suppliers are shared, whereas the verification and tracking efforts are often concentrated. As a result, firms rarely put in as much effort in this regard as they should. It often requires outside activists and third parties focused on social and environmental improvement to push a company to change. The journey of Nike is a classic example. It took revelations by activist Jeff Ballinger, protests at the Barcelona Olympics, and protests by students on college campuses to end the use of sweatshops by the company. The company has since moved on to become a leader in social responsibility. Given the challenge of the tragedy of the commons, activists will always have a significant role to play in pushing firms to consider the social and environmental pillars when making sourcing decisions.

Information

Good information continues to be one of the biggest challenges to improved supply chain sustainability. The absence of standards for measurement and reporting has led to claims of improvement that are often not verifiable. In the short term, this has led to company-specific standards and an explosion of certifications and certifying agencies. Companies talk of working toward a common set of standards, but it is unlikely that such standards will emerge because incentives are not aligned across different firms. This poses a challenge both within firms and across supply chains when it comes to improving sustainability. The C.A.F.E. standards and supplier rating are an effort by Starbucks to encourage suppliers to focus on sustainability. Plambeck (2007) describes efforts within Walmart to measure and motivate both suppliers and associates. To reduce packaging, Walmart implemented a web-based scorecard that evaluated the packaging of each product along nine metrics, such as cube utilization and recycled content. This scorecard was used to measure and recognize improvements in packaging. Even though universal standards may not be possible, the use of consistent scorecards within a supply chain can go a long way toward aligning the sustainability efforts of all members of the extended supply chain.

Pricing

As discussed in Chapter 16, intelligent use of differential pricing can improve the utilization of assets, leading to resource reduction. Planes that are fuller through differential pricing improve airline profits while reducing the fuel consumption and emissions per passenger. This also delays the need for additional capacity in the form of new planes. Consumption visibility and differential pricing by load or time of day have the potential to make a significant difference in the usage of energy by consumers. Some studies have found that when people can see how much electricity they are using and the impact of turning off different appliances, their usage decreases by between 10 to 15 percent. If this visibility is simultaneously coupled with lower-price off-peak electricity, there is a potential to reduce peak load demand. In general, lower peaks and improved utilization of assets through differential pricing improves both the environmental and economic performance of a firm.

One of the biggest challenges to improved sustainability of a supply chain is changing the customer's willingness to pay for a product that is produced and distributed by a supply chain in a more sustainable manner but ends up costing more. According to a 2011 survey conducted by the market research firm Mintel for the food service industry, customers are willing to pay a mere 1 to 5 percent more for sustainable fare. The lack of willingness to pay also extends to corporations when making supply chain choices. For example, Walmart has not hit its targets for the use of renewable energy because these sources have higher costs compared with other sources of energy. Walmart's use of renewable energy in 2013 declined relative to 2012 because it was "unable to renegotiate an expiring contract with competitive pricing." Similarly, Starbucks classified its use of renewable energy as an area that "needs improvement" in its 2013 global responsibility report.

In the short term, government incentives can encourage customers and firms to behave more sustainably. In the long term, however, efforts toward increased sustainability will pick up speed only when customers place greater value on it, allowing supply chains to grow the supply chain surplus by being sustainable (despite higher costs).

17.5 CLOSED-LOOP SUPPLY CHAINS

As we discussed earlier, supply chains typically cause significant harm to the environment when their output ends up in a landfill. One of the biggest opportunities to improve sustainability is for firms to design products that use fewer resources and can be recycled and remanufactured after use. An example of a commonly remanufactured product is retreaded tires. Retreaded tires are used in trucks, buses, heavy construction and agricultural equipment, aircraft, and passenger vehicles. Retreaded tires are cheaper to produce and tires can be retreaded multiple times. Despite these advantages, retreaded tires accounted for only "about 3 percent of total sales by U.S. firms within the tires sector" between 2009 and 2011.[14] In 2011, production at U.S. tire retreaders was limited by the availability of used tire casings. The example of tires raises two important questions that arise in every industry: Why do we not see more instances of remanufacturing? What can be done to increase the return of used product (like tire casings)? The extent of recycling or remanufacturing depends on the following factors:

- The incentive to recycle or remanufacture
- The cost to recycle or remanufacture

Unless they are forced to, manufacturers have typically limited their efforts to design recyclable/remanufacturable products. Even when such products have been designed, recycling rates have often been low because of the lack of customer and manufacturer effort. The absence of successful recycling and remanufacturing can be explained by the tragedy of the commons, manufacturer concerns that remanufactured products may cannibalize demand from new products, and the lack of effort from customers to return used product. The cost of a product ending up in a landfill is borne by society (until recently, it has been free for manufacturers), whereas the additional cost of recyclable products is borne by each manufacturer. This decreases any incentive for manufacturers to make this effort. Calcott and Walls (2000) discuss theoretical models for the design of incentives to encourage design of products that are environmentally friendly. To encourage the appropriate behavior in supply chains, it is important that the polluter pays the cost inflicted on society (referred to as the *polluter pays principle*). Policies that are consistent with this idea include take-back mandates, advance disposal fees, and deposit–refund programs. The WEEE Directive is an example of a take-back mandate in which producers bear responsibility for end-of-life electrical and electronic waste in Europe. Producers bear both the financial and physical responsibility for meeting recycling or recovery targets. Advance disposal fees have been used for materials such as motor oil, antifreeze, tires, and solvents that are hard to dispose of. California charges an electronic waste recycling fee for any product sold with a screen. Deposit–refund programs are used for cans and bottles when customers pay a fixed deposit when they purchase soda or beer. A refund is then provided when customers bring back empty cans or bottles. In each example cited here, the goal is to put a cost in place that encourages reduction of waste and a positive incentive that encourages increased recycling.

The fear of cannibalization of demand for new products is a major deterrent to remanufacturing. Manufacturers are concerned that sales of the remanufactured product will reduce demand for new products, thus hurting firm profitability. The impact of cannibalization depends on the presence of distinct customer segments for the product. If there are at least two distinct customer segments, remanufacturing can be used to target the lower-price segment while new products

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[14]U.S. International Trade Commission, "Remanufactured Goods: An Overview of the U.S. and Global Industries, Markets, and Trade," October 2012.

target the higher-price segment (see Chapter 16). This strategy is used by tire manufacturers for truck tires, as remanufacturing allows strong brands to compete with lower-end brands without diluting the value of the new product. When there are two distinct segments, remanufacturing can help rather than hurt profits. However, when this distinction between segments is not feasible, customers are likely to be strategic and purchase the remanufactured product at a lower price, leading to cannibalization of demand for new products.

If a customer could be charged for pollution based on the precise cost to society, customers are likely to return recyclable products at a high rate. The challenge, however, is that most people pay a fixed monthly fee for collection, hauling, and dumping of trash. In such a setting, people have a lower incentive to recycle. A “pay as you throw” (PAYT) model, in which the cost incurred is proportional to the amount of garbage thrown out, is likely to increase recycling. Most communities with PAYT require customers to use specific garbage bags, for which they are charged. This approach links people’s spending on garbage to the number of bags they use, thus rewarding them for recycling a product rather than dumping it with the garbage.

Even when the right incentives are in place, the actual cost of recycling or remanufacturing has a significant impact on the extent of recycling. Much of the cost in such instances is linked to the logistics cost of collection and transportation. Consumer electronics are a classic example for which the high cost of collection and transportation hurts recycling and remanufacturing. Most of the consumer electronics are manufactured in Asia, with large consumer markets in Europe and North America. Not only is it expensive to recover used electronics from customers, but it is also very expensive to ship any recycled parts back to Asia for remanufacturing. This makes the cost high enough that remanufactured products are often not cheaper to produce than new ones. One company that is working to reduce the cost of remanufacturing smartphones is Brightstar, one of the biggest providers of refurbishing services for the telecom sector. As smartphone hardware becomes more standardized and subject to less change (with most of the change shifting to software), Brightstar, with local refurbishing centers in North America, is hoping to provide low-cost refurbished handsets. The use of standardized parts that make the remanufacturing process cheap, along with local presence that lowers transportation cost, increase the likelihood of successful remanufacturing in this space.

Single-use cameras were one of the most successful examples of a closed-loop supply chain with remanufacturing. This was an instance in which remanufacturing was successful because all the incentives were right and the costs were low. The cost of collection was low because customers naturally brought their single-use cameras to a retailer for printing pictures. No further incentives were needed to encourage customer returns. Manufacturers had the right incentive because remanufacturing saved the manufacturers money and there was no difference in price between a remanufactured camera and a new one. There are few other examples, however, with the same success. The right incentives for both manufacturers and customers, along with well-developed reverse supply chains, will be required for greater use of recycling and remanufacturing.

17.6 THE PRICING OF SUSTAINABILITY

For individuals and firms to focus on sustainability, it is crucial that they internalize the “monetary value” of the social or environmental cost of their actions. Firms are structured to naturally account for all factors that they have to pay for. Every effort is put into place to reduce these costs. For example, firms optimize the use of water based on its cost. This cost does not, however, include the impact of a water shortage on the firm as well as the surrounding community. As a result, firms use more water than they would if they had to internalize the cost of future shortages on society. Similar inefficiencies exist along a variety of social and environmental factors. To improve sustainability in the supply chain, it is thus important to incorporate suitable prices for the social and environmental impacts of different actions such as emissions. There are, however, significant challenges to setting these prices appropriately. We discuss some of these challenges in the context of emission pricing.

Pricing of Emissions

Decision makers all over the world have devoted significant attention to reducing GHG emissions. As discussed in the tragedy of the commons, firms will not put sufficient effort into reducing GHGs unless they are "forced" to reduce emissions or required to pay for the social cost of their emission. The policies proposed include technology mandates, performance standards, and emissions pricing. The theoretical attraction of emissions pricing is that it has the potential to achieve emissions reduction at lower cost than other approaches. A study by the OECD found that charging for emissions was more cost effective than subsidies or mandates in reducing carbon dioxide emissions.[15] Even though there is general agreement on the need for emissions pricing, finding the right price is challenging.

Two approaches used to price emissions are a carbon tax and a cap-and-trade system. By charging for emissions, both methods encourage firms to reduce emissions per unit of output. The prices in the two cases, however, are set differently. Under a carbon tax, the price of emissions is the tax rate set directly by the regulatory authority. A carbon tax fixes the price of emissions, but the quantity of emissions is decided by the emitters. Under a cap-and-trade system, the total quantity of emissions is set by the regulatory authority and the price is set indirectly. The regulatory authority sets an overall limit on the quantity of emissions by providing allowances equal to this limit. Firms that emit less than their share of allowances can sell the surplus allowances to firms that emit more than their share. This market for allowances then yields a price of emissions. A cap-and-trade system fixes the quantity of emissions through the allowances but the price of emissions is allowed to change. A seminal paper discussing the relative merits of setting prices versus quantities was written by Martin Weitzman in 1974. The difficulty in both approaches arises because regulators do not have sufficient information of the cost to individual firms of reducing emissions or the cost to society of emissions. In the carbon tax approach, this lack of information makes it difficult to set the correct tax. Setting a tax that is too low results in insufficient effort by firms to reduce emissions. In contrast, setting a tax that is too high forces firms to make emission reduction efforts that are too expensive. In the cap-and-trade approach, the lack of information makes it difficult to decide the quota of emission allowances. Too large a quota results in too low a price of emissions, whereas too small a quota results in too high a price.

Goulder and Schein (2013) provide an excellent review of both a carbon tax and cap-and-trade. Rather than a pure cap-and-trade mechanism, in which the market sets prices under all circumstances, they recommend a hybrid version of the cap-and-trade, in which the traded allowances have a floor price as well as a ceiling. The ceiling is enforced by adding extra allowances when the ceiling price is hit (the regulatory authority sells unlimited allowances at the ceiling price), whereas the floor is enforced by removing allowances (the regulatory authority purchases any number of allowances available for sale at the floor price). A major advantage of the hybrid cap-and-trade relative to a pure cap-and-trade is that it limits the volatility in the price of emissions allowing businesses to better plan their environmental activities. Goulder and Schein discuss the following dimensions along which any emissions pricing mechanism should be evaluated:

- ***Cost of administration:*** The cost of administering an emissions pricing policy depends on the number of sources that need to be monitored. Charging the ultimate emitters can be very cumbersome, given the millions of such entities. It can be cheaper to charge the upstream suppliers (such as energy supply companies) whose products end up as emissions because there are fewer of them (compared with the ultimate emitters). Both carbon taxes and cap-and-trade can potentially be applied to upstream suppliers.
- ***Price volatility:*** Businesses tend to prefer low price volatility because it allows them to better plan their sustainability activities. A carbon tax fixes the price of emissions, whereas a cap-and-trade system displays price volatility. A hybrid cap-and-trade system limits price

[15] "Climate and Carbon: Aligning Prices and Policies," OECD Environment Policy Paper No. 1, October 2013.

volatility, given a floor and ceiling price. Price volatility in a cap-and-trade system can be reduced by allowing intertemporal banking, in which firms can apply future allowances to current emissions or save current allowances for future emissions.

- ***Emission uncertainty:*** A cap-and-trade system caps the emissions (except when the ceiling price is hit), whereas a carbon tax can potentially have high emissions if the cost of reducing emissions is greater than the tax. Some environmental activists have opposed the carbon tax because it does not guarantee a drop in emissions.
- ***New information uncertainty:*** As new information becomes available about the costs and benefits of emission reduction (for example, with the introduction of new technology), the price of emissions should adjust accordingly. A hybrid cap-and-trade mechanism with the possibility of intertemporal banking (for allowances to be saved for the future or borrowed from the future) is better able to adjust the price of emissions based on new information compared with a carbon tax.
- ***Industry competitiveness:*** A country or state that is further along on emission pricing can potentially hurt the competitiveness of its own emission intensive firms relative to firms operating outside its borders. In theory, a tax at the border for imported goods (based on origin) and an allowance for exported goods (based on destination) can level the playing field. In practice, however, such an approach is administratively complex in most instances because it requires different levels of tax based on origin of imports and destination for exports. This complexity makes border adjustments very difficult to implement in practice.
- ***Wealth transfer to energy-exporting countries:*** For a country that imports most of its energy supplies, a cap-and-trade system has the potential to shift wealth to energy-exporting countries. The price on emissions is designed to encourage lower consumption of fuels like crude oil. A cartel of oil-producing countries can potentially take advantage of a cap-and-trade mechanism by reducing supply of crude below the level that would be achieved with a price on emissions. This would lower the price of emissions under cap-and-trade to zero because the demand for allowances would be less than the supply. The oil producers would gain revenue because the reduced supply would raise the price of oil. Instead of the local government gaining revenue from the auction of allowances, the oil producers would extract that revenue in the form of higher oil prices. This transfer of wealth does not occur with a carbon tax and is limited by a hybrid cap-and-trade system. Such an outcome is also limited if the energy supply market is competitive, because supply cannot be constrained in a competitive market.
- ***Revenue neutrality:*** Several studies have indicated that the costs of emission pricing policies are minimized if any government revenue from these policies (in the form of a tax or revenue from auctioning emission allowances) is returned to the consumers in the form of a reduction in the marginal rates of pre-existing income or sales taxes.

There is general agreement that putting an explicit price on emissions is more cost effective than other policy choices in reducing emissions. In this context, carbon taxes are simple to administer and provide a fixed price that businesses can plan for. They do not, however, guarantee a decrease in emissions and it is difficult for the regulatory authority to determine the optimal tax rate. Cap-and-trade mechanisms can be used to limit emissions and are flexible enough to incorporate new information as it becomes available but may display significant price volatility. To limit price volatility, it is best to implement cap-and-trade with a price floor as well as ceiling and allow intertemporal banking of emission allowances.

17.7 SUMMARY OF LEARNING OBJECTIVES

1. ***Understand the importance of sustainability in a supply chain.*** As supply chains have globalized and emerging countries have grown, it has become increasingly clear that the world's resources and environment will not be able to support this growth unless supply chains become more sustainable. Besides the need to make the world more sustainable, an increased focus on sustainability has allowed some supply chains to reduce risk, become more efficient, and attract some customers who value these efforts.

2. *Discuss the challenge to sustainability posed by the tragedy of the commons.* Many actions that improve sustainability of a supply chain impose costs that are local (to an individual, a firm, supply chain, or country) but provide common benefits that are more global. In contrast, a disregard for sustainability provides benefits that are local but costs that are shared globally. As a result, encouraging sustainability without some external pressure, in the form of either a public mandate or an economic incentive, can be difficult.

3. *Describe key dimensions of sustainability for a supply chain.* Supply chain sustainability can be evaluated in terms of social, environmental, and economic impacts. The social pillar includes the impact on the workforce, customers, and society. The environmental pillar includes resource reduction, emission reduction, and environmental product innovation.

4. *Understand the role of incentives for successful sustainability efforts.* The tragedy of the commons makes it difficult to improve sustainability efforts by firms and individuals without some external pressure. To decrease resource consumption and increase recycling and remanufacturing, a suitable approach is to tax the producer to encourage resource reduction and reward the recycler to increase the percentage recycled. A price on emissions is the most cost-effective way of reducing emissions. Emissions can be priced through either a carbon tax or a hybrid cap-and-trade mechanism.

Discussion Questions

1. What are some benefits to improved sustainability of a supply chain?
2. What are some challenges that limit the effort put in by supply chains to improve sustainability?
3. Describe the "tragedy of the commons" in the context of supply chain sustainability. What are some "mutually coercive" mechanisms that could be implemented to encourage supply chain sustainability?
4. What are some problems with firms reporting their sustainability performance based on metrics that do not consider their extended supply chain?
5. Study the CSR reports for a couple of firms. Identify actions across a few supply chain drivers that have improved sustainability. Which areas has the company found challenging to improve?
6. Discuss some reasons that we do not see more recycling or remanufacturing of products.
7. The European Union emission trading scheme saw a lot of price volatility in Phase I. Many academics pointed out that much of the price volatility occurred because the program prevented the banking of allowances from the first phase to the second. Discuss why the banking of allowances over time may reduce price volatility in a cap-and-trade scheme.

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Information Technology in a Supply Chain

LEARNING OBJECTIVES

After reading this chapter, you will be able to

1. Understand the importance of information and information technology in a supply chain.
2. Know, at a high level, how each supply chain driver uses information.
3. Understand the major applications of supply chain information technology and the processes that they enable.

Information is crucial to the performance of a supply chain because it provides the basis on which supply chain managers make decisions. Information technology consists of the tools used to gain awareness of information, analyze this information, and execute on it to improve the performance of the supply chain. In this chapter, we explore the importance of information, its uses, and the technologies that enable supply chain managers to use information to make better decisions.

THE ROLE OF IT IN A SUPPLY CHAIN

Information is a key supply chain driver because it serves as the glue that allows the other supply chain drivers to work together with the goal of creating an integrated, coordinated supply chain. Information is crucial to supply chain performance because it provides the foundation on which supply chain processes execute transactions and managers make decisions. Without information, a manager cannot know what customers want, how much inventory is in stock, and when more product should be produced or shipped. In short, information provides supply chain visibility, allowing managers to make decisions to improve the supply chain's performance.

IT consists of the hardware, software, and people throughout a supply chain that gather, analyze, and execute upon information. IT serves as the eyes and ears (and sometimes a portion of the brain) of management in a supply chain, capturing and analyzing the information necessary to make a good decision. For instance, an IT system at a manufacturer may show the finished goods inventory at different stages of the supply chain and also provide the optimal production plan and level of inventory based on demand and supply information.

Using IT systems to capture and analyze information can have a significant impact on a firm's performance. For example, a major manufacturer of computer workstations and servers found that most of its information on customer demand was not being used to set production schedules and inventory levels. The manufacturing group lacked this demand information, which essentially forced it to make inventory and production decisions blindly. By installing a supply chain software system, the company was able to gather and analyze demand data to produce recommended stocking levels. Using the IT system enabled the company to cut its inventory in half, because managers could now make decisions based on customer demand information rather than manufacturing's educated guesses. Large impacts such as this underscore the importance of IT as a driver of supply chain performance.

Availability and analysis of information to drive decision making is a key to the success of a supply chain. Companies that have built their success on the availability and analysis of information include Seven-Eleven Japan, Walmart, Amazon, UPS, and Netflix. To support effective supply chain decisions, information must have the following characteristics:

1. ***Information must be accurate.*** Without information that gives a true picture of the state of the supply chain, it is difficult to make good decisions. That is not to say that all information must be 100 percent correct, but rather that the available data paint a picture that is at least directionally correct.
2. ***Information must be accessible in a timely manner.*** Accurate information often exists, but by the time it becomes available, it is either out of date or it is not in an accessible form. To make good decisions, a manager needs to have up-to-date information that is easily accessible.
3. ***Information must be of the right kind.*** Decision makers need information that they can use. Often companies have large amounts of data that are not helpful in making a decision. Companies must think about what information should be recorded so that valuable resources are not wasted collecting meaningless data while important data go unrecorded.
4. ***Information must be shared.*** A supply chain can be effective only if all its stakeholders share a common view of the information that they use to make business decisions. Different information with different stakeholders results in misaligned action plans that hurt supply chain performance.

Information is used when making a wide variety of decisions about each supply chain driver, as discussed next.

1. ***Facility.*** Determining the location, capacity, and schedules of a facility requires information on the trade-offs among efficiency and flexibility, demand, exchange rates, taxes, and so on (see Chapters 4, 5, and 6). Walmart's suppliers, for instance, use the demand information from Walmart's stores to set their production schedules. Walmart uses demand information to determine where to place its new stores and cross-docking facilities.
2. ***Inventory.*** Setting optimal inventory policies requires information that includes demand patterns, cost of carrying inventory, costs of stocking out, and costs of ordering (see Chapters 11, 12, and 13). For example, Walmart collects detailed demand, cost, margin, and supplier information to make these inventory policy decisions.
3. ***Transportation.*** Deciding on transportation networks, routings, modes, shipments, and vendors requires information about costs, customer locations, and shipment sizes to make good decisions (see Chapter 14). Walmart uses information to tightly integrate its operations with those of its suppliers. This integration allows Walmart to implement cross-docking in its transportation network, saving on both inventory and transportation costs.

4. ***Sourcing.*** Information on product margins, prices, quality, delivery lead times, and so on are all important in making sourcing decisions. Given sourcing deals with inter-enterprise transactions, a wide range of transactional information must be recorded to execute operations, even once sourcing decisions have been made.
5. ***Pricing and revenue management.*** To set pricing policies, one needs information on demand, both its volume and various customer segments' willingness to pay, and on many supply issues, such as the product margin, lead time, and availability. Using this information, firms can make intelligent pricing decisions to improve their supply chain profitability.

In summary, information is crucial to making good supply chain decisions at all three levels of decision making (strategy, planning, and operations) and in each of the other supply chain drivers (facilities, inventory, transportation, sourcing, and pricing). IT enables not only the gathering of these data to create supply chain visibility, but also the analysis of these data so that the supply chain decisions made will maximize profitability.

THE SUPPLY CHAIN IT FRAMEWORK

We develop a framework that managers can use to understand the role of IT within the supply chain. At its core, IT provides access and reporting of supply chain transaction data. More advanced IT systems then layer on a level of analytics that uses transaction data to proactively improve supply chain performance. For example, as a baseline, good IT systems will record and report demand, inventory, and fulfillment information for Amazon. IT systems that provide analytics then allow Amazon to decide whether to open new distribution centers and how to stock them.

Given that both reporting and analysis require the availability of accurate transaction data, enterprise software forms the foundation of a supply chain IT system. This is a space that has matured from the early 1990s to the early 2000s, with SAP and Oracle as the two major players. During this period, enterprise software providers such as SAP and Oracle worked to extend their analytics capabilities, while best-of-breed analytics providers such as i2 and Manugistics attempted to provide transaction level capability. The winners were the enterprise software providers, and the first decade of the twenty-first century saw significant consolidation across the industry. We propose that further evolution of supply chain IT can be viewed in the context of the supply chain macro processes discussed in Chapter 1.

The Supply Chain Macro Processes

The emergence of supply chain management has broadened the scope across which companies make decisions. This scope has expanded from trying to optimize performance across the division, to the enterprise, and now to the entire supply chain. This broadening of scope emphasizes the importance of including processes all along the supply chain when making decisions. From an enterprise's perspective, all processes within its supply chain can be categorized into three main areas: processes focused downstream, processes focused internally, and processes focused upstream. We use this classification to define the three macro supply chain processes (see Chapter 1) as follows:

- ***Customer relationship management (CRM).*** Processes that focus on downstream interactions between the enterprise and its customers.
- ***Internal supply chain management (ISCM).*** Processes that focus on internal operations within the enterprise. Note that the software industry commonly calls this *supply chain management* (without the word *internal*), even though the focus is entirely within the enterprise. In our definition, supply chain management includes all three macro processes—CRM, ISCM, and SRM.
- ***Supplier relationship management (SRM).*** Processes that focus on upstream interactions between the enterprise and its suppliers.

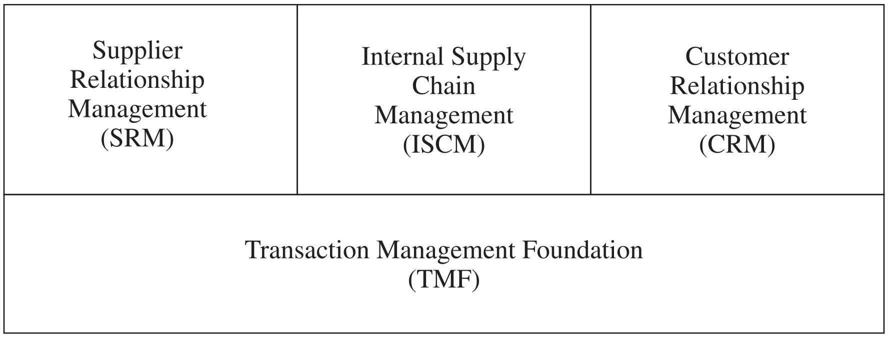

FIGURE 1 The Macro Processes in a Supply Chain

All operation and analytics related to the macro processes rest on the *transaction management foundation* (TMF), which includes basic enterprise resource planning (ERP) systems (and its components, such as financials and human resources), infrastructure software, and integration software. TMF software is necessary for the three macro processes to function and to communicate with one another. The relationship between the three macro processes and the transaction management foundation can be seen in Figure 1.

Why Focus on the Macro Processes?

As the performance of an enterprise becomes more closely linked to the performance of its supply chain, it is crucial that firms focus on these macro processes. As we have emphasized in this book, good supply chain management is not a zero-sum game in which one stage of the supply chain increases profits at the expense of another. Good supply chain management instead attempts to grow the supply chain surplus, which requires each firm to expand the scope beyond internal processes and look at the entire supply chain in terms of the three macro processes to achieve breakthrough performance. A good supply chain coordinates all the macro processes across all stages. Apple is an example of a company that has coordinated all macro processes to introduce and sell blockbuster products such as the iPhone. Apple has been very successful in its interactions with customers not only in designing products that meet their needs but also in operating Apple retail as a successful and profitable endeavor. All its products are designed in-house but manufactured by a third party. Despite this, Apple has managed the release of new products to effectively meet huge demand. Strong coordination across all the macro processes has been fundamental for the level of success achieved by Apple.

We now discuss each of the macro processes and the role played by IT.

CUSTOMER RELATIONSHIP MANAGEMENT

The CRM macro process consists of processes that take place between an enterprise and its customers downstream in the supply chain. The goal of the CRM macro process is to generate customer demand and facilitate transmission and tracking of orders. Weakness in this process results in demand being lost and a poor customer experience because orders are not processed and executed effectively. The key processes under CRM are as follows:

- ***Marketing.*** Marketing processes involve decisions regarding which customers to target, how to target customers, what products to offer, how to price products, and how to manage the actual campaigns that target customers. Good IT systems in the marketing area within CRM provide analytics that improve the marketing decisions on pricing, product profitability, and customer profitability, among other functions.

- ***Sell.*** The sell process focuses on making an actual sale to a customer (compared to marketing, in which processes are more focused on planning whom to sell to and what to sell). The sell process includes providing the sales force with the information it needs to make a sale and then execute the actual sale. Executing the sale may require the salesperson (or the customer) to build and configure orders by choosing among a variety of options and features. The sell process also requires such functionality as the ability to quote due dates and access information related to a customer order. Good IT systems support sales force automation, configuration, and personalization to improve the sell process.
- ***Order management.*** The process of managing customer orders as they flow through an enterprise is important for the customer to track an order and for the enterprise to plan and execute order fulfillment. This process ties together demand from the customer with supply from the enterprise. Good IT systems enable visibility of orders across the various stages that an order flows through before reaching the customer.
- ***Call/service center.*** A call/service center is often the primary point of contact between a company and its customers. A call/service center helps customers place orders, suggests products, solves problems, and provides information on order status. Good IT systems have helped improve call/service center operations by facilitating and reducing work done by customer service representatives and by routing customers to representatives who are best suited to service their request.

Amazon has done an excellent job of using IT to enhance its CRM process. The company customizes the products presented to suit the individual customer (based on an analysis of customer preferences from past history and current clicks). Quick ordering is facilitated by systems that allow one-click orders. The order is then visible to the customer until it is delivered. In the rare instances that a customer uses the call center, systems are in place to support a positive experience, including offering a callback if the call center is heavily loaded.

The five largest CRM software providers in 2012 (as reported by Gartner) were Salesforce.com (14.0 percent), SAP (12.9 percent), Oracle (11.1 percent), Microsoft (6.3 percent), and IBM (3.6 percent).[1]

INTERNAL SUPPLY CHAIN MANAGEMENT

ISCM, as we discussed earlier, is focused on operations *internal* to the enterprise. ISCM includes all processes involved in planning for and fulfilling a customer order. The various processes included in ISCM are as follows:

- ***Strategic planning.*** This process focuses on the network design of the supply chain. Key decisions include location and capacity planning of facilities. For more details on strategic planning decisions, see Chapters 5 and 6.
- ***Demand planning.*** Demand planning consists of forecasting demand and analyzing the impact on demand of demand management tools such as pricing and promotions. For more discussion of this process, see Chapter 7 on demand forecasting as well as Chapters 9 and 15 on pricing.
- ***Supply planning.*** The supply planning process takes as an input the demand forecasts produced by demand planning and the resources made available by strategic planning, and then produces an optimal plan to meet this demand. Factory planning and inventory planning capabilities are typically provided by supply planning software. For more discussion of this process, see Chapters 8 and 9 on sales and operations planning and Chapters 11 and 12 on inventory management.

[1]www.forbes.com/sites/louiscolumbus/2013/04/26/2013-crm-market-share-update-40-of-crm-systems-sold-are-saas-based, accessed July 25, 2014.

- ***Fulfillment.*** Once a plan is in place to supply the demand, it must be executed. The fulfillment process links each order to a specific supply source and means of transportation. The software applications that typically fall into the fulfillment segment are transportation and warehousing management applications. For more discussion of transportation, see Chapter 14 on transportation.
- ***Field service.*** Finally, after the product has been delivered to the customer, it eventually must be serviced. Service processes focus on setting inventory levels for spare parts as well as scheduling service calls. Some of the scheduling issues here are handled in a similar manner to aggregate planning, and the inventory issues are the typical inventory management problems.

Given that the ISCM macro process aims to fulfill demand that is generated by CRM processes, strong integration is needed between the ISCM and CRM macro processes. When forecasting demand, interaction with CRM is essential, as the CRM applications are touching the customer and have the most data and insight on customer behavior. Similarly, the ISCM processes should have strong integration with the SRM macro process. Supply planning, fulfillment, and field service are all dependent on suppliers and therefore on the SRM processes. It is of little use for your factory to have the production capacity to meet demand if your supplier cannot supply the parts to make your product. Order management, which we discussed under CRM, must integrate closely with fulfillment and be an input for effective demand planning. Again, extended supply chain management requires that we integrate across the macro processes.

Successful ISCM software providers have helped improve decision making within ISCM processes. Good integration with CRM and SRM, however, is still largely inadequate at both the organizational and software levels. Future opportunities are likely to arise partly in improving each ISCM process, but even more so in improving integration with CRM and SRM.

The top five ISCM vendors in 2012 (as reported by Gartner) were SAP, Oracle, JDA, Manhattan Associates, and Epicor. SAP ($1.721 billion) and Oracle ($1.453 billion) had significantly higher revenues than the other three ($0.724 billion combined).[2]

SUPPLIER RELATIONSHIP MANAGEMENT

SRM includes those processes focused on the interaction between the enterprise and suppliers that are upstream in the supply chain. There is a natural fit between SRM processes and the ISCM processes, as integrating supplier constraints is crucial when creating internal plans. The major SRM processes are as follows:

- ***Design collaboration.*** This software aims to improve the design of products through collaboration between manufacturers and suppliers. The software facilitates the joint selection (with suppliers) of components that have positive supply chain characteristics such as ease of manufacturability or commonality across several end products. Other design collaboration activities include the sharing of engineering change orders between a manufacturer and its suppliers. This eliminates the costly delays that occur when several suppliers are designing components for the manufacturer's product concurrently.
- ***Source.*** Sourcing software assists in the qualification of suppliers and helps in supplier selection, contract management, and supplier evaluation. An important objective is to analyze the amount that an enterprise spends with each supplier, often revealing valuable trends or areas for improvement. Suppliers are evaluated along several key criteria, including lead time, reliability, quality, and price. This evaluation helps improve supplier performance and aids in supplier selection. Contract management is also an important part of sourcing, as many supplier contracts have complex details that must be tracked (such as volume-related price reductions). Successful software in this area helps analyze supplier performance and manage contracts.

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[2]www.mmh.com/article/top_20_scm_software_suppliers_2013, accessed July 25, 2014.

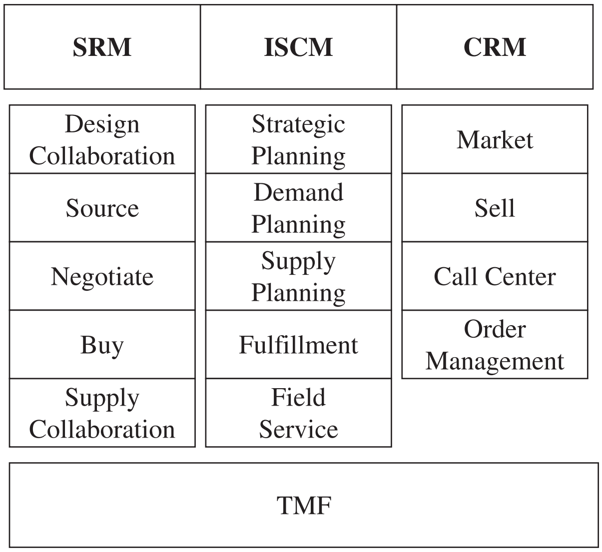

FIGURE 2 The Macro Processes and Their Associated Processes

- ***Negotiate.*** Negotiations with suppliers involve many steps, starting with a request for quote (RFQ). The negotiation process may also include the design and execution of auctions. The goal of this process is to negotiate an effective contract that specifies price and delivery parameters for a supplier in a way that best matches the enterprise's needs. Successful software automates the RFQ process and the execution of auctions.
- ***Buy.*** "Buy" software executes the actual procurement of material from suppliers. This includes the creation, management, and approval of purchase orders. Successful software in this area automates the procurement process and helps decrease processing cost and time.
- ***Supply collaboration.*** Once an agreement for supply is established between the enterprise and a supplier, supply chain performance can be improved by collaborating on forecasts, production plans, and inventory levels. The goal of collaboration is to ensure a common plan across the supply chain. Good software in this area should be able to facilitate collaborative forecasting and planning in a supply chain.

Significant improvement in supply chain performance can be achieved if SRM processes are well integrated with appropriate CRM and ISCM processes. For instance, when designing a product, incorporating input from customers is a natural way to improve the design. This requires inputs from processes within CRM. Sourcing, negotiating, buying, and collaborating tie primarily into ISCM, as the supplier inputs are needed to produce and execute an optimal plan. However, even these segments need to interface with CRM processes such as order management. Again, the theme of integrating the three macro processes is crucial for improved supply chain performance.

The SRM space is highly fragmented in terms of software providers and not as well defined as CRM and ISCM. Among the larger players, SAP and Oracle have SRM functionality in their software. There are many niche players, however, that focus on different aspects of SRM.

All three macro processes and their associated processes can be seen in Figure 2.

THE TRANSACTION MANAGEMENT FOUNDATION

The transaction management foundation is the historical home of the largest enterprise software players. In the early 1990s, when much of the thinking in supply chain management was just getting off the ground and ERP systems were rapidly gaining popularity, there was little focus on the three macro processes we discussed earlier. In fact, there was little emphasis on software applications focused on improving decisions through analysis. Instead, the focus at that time was on building transaction management and process automation systems that proved to be the foundation for future decision support applications. These systems excelled at the automation of simple transactions and processes and the creation of an integrated way to store and view data across the division (and sometimes the enterprise).

The huge demand for these systems during the 1990s drove the ERP players to become the largest enterprise software companies. According to Gartner, the top five ERP software vendors in 2012 were SAP, Oracle, Sage Group, Infor Global Solutions, and Microsoft.[3]

The real value of the transaction management foundation can be extracted only if decision making within the supply chain is improved. Thus, most recent growth in enterprise software has come from companies focused on improving decision making in the three macro processes. This has set the stage for what we are seeing today and will continue to see in the future—the realignment of the ERP companies into CRM, ISCM, and SRM companies. Already, the majority of ERP players' revenue comes from applications in the three macro processes. A major advantage that ERP players have relative to best-of-breed providers is the inherent ability to integrate across the three macro process, often through the transaction management foundation. ERP players that focus on integrating across the macro processes along with developing good functionality in one or more macro process will continue to occupy a position of strength. The goal of a successful IT system is ultimately to help coordinate decisions and actions across the supply chain. This can happen only if IT supports the macro processes to coordinate and run as one rather than as disparate silos, as shown in Figure 3.

THE FUTURE OF IT IN THE SUPPLY CHAIN

At the highest level, we believe that the three SCM macro processes will continue to drive the evolution of supply chain IT. Although there is still plenty of room to improve the visibility and reporting of supply chain information, the relative focus on improved analysis to support decision making will continue to grow. The following important trends will affect IT in the supply chain:

1. The growth in cloud and software as a service (SaaS)
2. Increased availability of real-time data

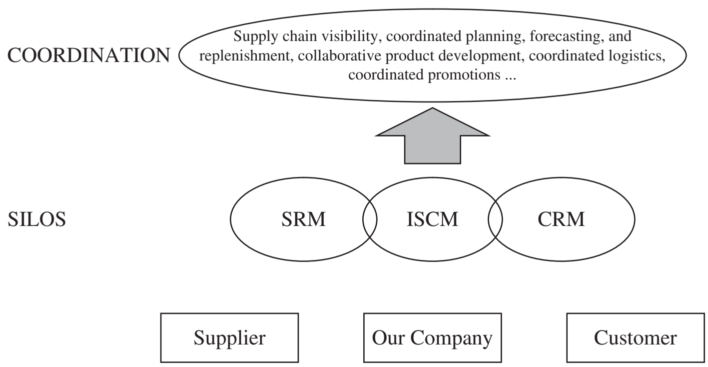

FIGURE 3 The Goal of Supply Chain IT: From Silos to Coordination

[3]www.forbes.com/sites/louiscolumbus/2013/05/12/2013-erp-market-share-update-sap-solidifies-market-leadership, accessed on July 25, 2014.

3. Increased use of mobile technology
4. Increased use of social media

SaaS is defined as software that is owned, delivered, and managed remotely through the cloud. Salesforce.com is one of the best-known pure SaaS supply chain software providers (in CRM). Gartner has predicted that SaaS (which made up about 10 percent of the enterprise software market in 2009) will grow from $13.5 billion in 2011 to $32.8 billion in 2016. CRM will continue to be the largest sector within SaaS, forecast to grow at a rate of over 16 percent annually to $9 billion in 2016. Another example is transportation management systems, for which roughly a quarter of the revenues are from SaaS applications. This shift is likely to occur because SaaS provides lower startup and maintenance costs compared with applications that are deployed onsite. These factors are particularly important for small and mid-sized companies. Traditional enterprise software vendors, such as SAP, Oracle, and Microsoft, are increasing the availability of their software using the SaaS model. Cloud-based solutions fit naturally with supply chain management because they allow geographically dispersed entities to view common information and make decisions.

The availability of real-time information has exploded in most supply chains. Whereas current supply chain software is focused primarily on improving strategy and planning decisions (often at the corporate level) that are revisited infrequently, significant opportunity exists to devise software that will use real-time information to help frontline supply chain staff (such as that in transportation and warehousing) make smarter and faster decisions that are revisited frequently. The opportunity is to design systems that enable rapid insight based on real-time data. There is significant opportunity in flagging exceptions as well as the use of predictive analytics to improve the utilization of supply chain assets.

The increased use of mobile technology coupled with real-time information offers some supply chains an opportunity to better match demand to supply using differential pricing. An example is an initiative by Groupon called Groupon Now, which offers mobile users deals that are time and location specific. Businesses can improve profitability by offering deals when business is slow at specific locations. Consumers benefit from getting a deal when and where they want it. Such an approach is likely to be applicable in many supply chain settings.

Mobile technology, along with real-time information, has also allowed improved use of existing supply chain assets, often at a person-to-person level. The increased use of social media coupled with mobile technology has the potential to alter supply chains, especially around the last mile. In Stockholm, Sweden, the DHL supply chain has worked on MyWays, a new model for last-mile delivery. Through an app available on mobile devices, customers sign up for this delivery option. MyWays members are notified of the need for delivery and sign up for the delivery if it is close to a route they normally take—to their college, for example. Once delivery is made, the member gets credits that can be exchanged for cash. Airbnb and Uber are two examples of companies that have used social media and mobile devices to link individuals to rooms or transportation. There is a real opportunity in the future to use existing assets (such as a person traveling a route for MyWays or an idle car for Uber) to make supply chains more effective, as mobile technology and social media are used to connect the existing asset to the supply chain task at hand.

RISK MANAGEMENT IN IT

Several risks are associated with the use of IT in the supply chain, and the process of adding new supply chain capabilities with IT can be fraught with danger. The larger the change in the IT system, the greater is the risk of a negative impact on operations. The more ingrained IT becomes in companies, the greater is the risk that the firm will not be able to function properly if IT suffers a major failure. Here we discuss some of the major risks posed by using IT in the supply chain and some ideas for mitigating these risks.

The major areas of risk in IT can be divided into two broad categories. The first, and potentially the greater, is the risk involved with installing new IT systems. During the process of getting new IT systems running, a firm is forced to transition from the old processes it used in its operations to the new processes in its IT system. Here, trouble can be found in both business processes and in technical issues. On the business process side, new IT systems often require employees to operate according to new processes. These may be difficult to learn, take training to execute correctly, or may even be resisted outright by employees who prefer the old way of doing business. Getting the entire organization on board with the changes brought about by a new IT system is particularly difficult because top management is often not actively involved in making this transition. In addition to business process adjustments, tremendous technical hurdles must be overcome in getting new IT systems operational. The amount of integration that must take place between disparate systems is often overwhelming. When a firm switches to a new system without proper integration, the new system is often unable to perform all that was promised and sometimes even performs worse than the system it replaced. Even when the employees are bought into the new process and all the technical hurdles are overcome, it is often a delicate balance to actually make the transition over to the new system.

The second category of risk is that the more a firm relies on IT to make decisions and execute processes, the higher is the risk that any sort of IT problem, ranging from software glitches to power outages to viruses, can completely shut down a firm's operations. These are serious risks that a firm must plan to face. IT also poses a risk in that it tends to set processes in stone. Perhaps a system allows a process to be executed only one way; then the firm settles into a pattern of always doing this process that way. Obviously, there are great efficiency benefits to this, but the firm also runs the risk that the process is not up to the performance level of its competitors and that its systems make it difficult to change to newer, more effective processes.

Each of the major risk categories has its own mitigation strategies. With regard to implementing IT systems, keep three ideas in mind. The first is to install new IT systems in an incremental fashion rather than changing all processes at the same time (often referred to as a "big bang" approach). This allows a firm to limit the damage should things go wrong and to pinpoint problem areas during the installation process. Second, firms can run duplicate systems to make sure the new system is performing well. By this, we mean that the firm can keep its old system running at the same time the new one is running. If the new system runs into trouble or if the results seem too far off from the old one, the old system can be used, as it still exists. In fact, even before the new system is actually executing, it can be simulating (in parallel with the existing system) all the actions it would take. These proposed actions can be monitored to test how the new system will perform when it is actually activated. Finally, implement only the level of complexity that is needed. If certain capabilities or added complexities are unnecessary, they should be left out, as they can often increase the risk of the project without increasing the potential benefits. In essence, we want to tailor our IT systems to our supply chain needs, with risk reduction being one of those needs.

On the operational side, mitigation strategies include data backup systems, systems running in parallel in case one should suffer a problem, and a range of security software products that can help keep a company's systems safe. In addition, picking systems that have the flexibility to change if necessary can be important.

SUPPLY CHAIN IT IN PRACTICE

In addition to the sets of practical suggestions for each supply chain macro process discussed earlier, managers need to keep in mind several general ideas when they are making a decision regarding supply chain IT.

1. ***Select an IT system that addresses the company's key success factors.*** Every industry, and even companies within an industry, can have different key success factors. By key success factors, we mean the two or three elements that really determine whether a company is going to be successful. It is important to select supply chain IT systems that are able to give a company an advantage in the areas most crucial to its success. For instance, the ability to set inventory levels optimally is crucial in the consumer electronics business, in which product life cycles are short and inventory becomes obsolete quickly. However, inventory levels are not nearly as crucial for a chemical company, for which demand is fairly stable and the product has a long life cycle. For the chemical company, the key to success depends more on utilization of the production facility. Given these success factors, a consumer electronics company might pick a package that is strong in setting inventory levels even if it is weak in maximizing utilization of production capacity. However, the chemical company should choose a different product—one that excels at maximizing utilization even if its inventory components are not especially strong.

2. ***Take incremental steps and measure value.*** Some of the worst IT disasters result when companies try to implement IT systems in a wide variety of processes at the same time and end up with their projects being failures. The impact of these failures is amplified by the fact that many of a company's processes are tied up in the same debugging cycle all at once, causing productivity to come to a standstill. One way to help ensure the success of IT projects is to design them so they have incremental steps. For instance, instead of installing a complete supply chain system across your company all at once, start first by getting your demand planning up and running and then move on to supply planning. Along the way, make sure each step is adding value through increases in the performance of the three macro processes. This incremental approach does not mean that one should not take a big-picture perspective (in fact, one *must* take a big-picture perspective), but rather that the big-picture perspective should be implemented in digestible pieces.

3. ***Align the level of sophistication with the need for sophistication.*** Management must consider the depth to which an IT system deals with the firm's key success factors. There is a trade-off between the ease of implementing a system and the system's level of complexity. Therefore, it is important to consider just how much sophistication a company needs to achieve its goals and then to ensure that the system chosen matches that level. Erring on the less sophisticated side leaves the firm with a competitive weakness, whereas trying to be too sophisticated leads to a higher possibility of the entire system failing.

4. ***Use IT systems to support decision making, not to make decisions.*** Although the software available today can make many supply chain decisions for management, this does not mean that IT applications can make *all* the decisions. A mistake companies can make is installing a supply chain system and then reducing the amount of managerial effort it spends on supply chain issues. Management must keep its focus on the supply chain because as the competitive and customer landscapes change, there must be corresponding changes in the supply chain.

5. ***Think about the future.*** Although it is more difficult to make a decision about an IT system with the future rather than the present in mind, managers need to include the future state of the business in the decision process. If trends in a company's industry indicate that insignificant characteristics will become crucial in the future, managers must make sure that their IT choices take these trends into account. As IT systems often last for many more years than originally planned, managers need to spend time exploring how flexible the systems will be if—or rather, when—changes are required in the future. This exploration can go so far as to include the viability of the supply chain software developer itself. If it is unclear whether a company will be able to get support from a software company in the future, management needs to be sure that the other advantages of this product outweigh this disadvantage. The key here is to ensure not only that the software fits a company's current needs, but also, and even more important, that it will meet the company's future needs.

SUMMARY OF LEARNING OBJECTIVES

1. ***Understand the importance of information and information technology in a supply chain.*** Information is essential to making good supply chain decisions because it provides the broad view needed to make optimal decisions. IT provides the tools to gather this information and analyze it to make the best supply chain decisions.

2. *Know, at a high level, how each supply chain driver uses information.* Each of the supply chain drivers that we have discussed in previous chapters (facilities, inventory, transportation, sourcing, and pricing) requires information for decisions to be made. Information is the factual component on which decisions about each of the other drivers are based. In essence, information is the glue that holds the entire supply chain together and allows it to function, making information the most important supply chain driver.

3. *Understand the major applications of supply chain information technology and the processes that they enable.* A company's supply chain processes can be grouped into three main macro processes. CRM includes processes that enable interaction between an enterprise and its customers. ISCM includes processes focused on the internal operations of an enterprise. SRM includes processes that enable interaction between an enterprise and its suppliers. IT enables these processes, as well as the integration across these processes. Good IT systems allow not only the collection of data across the supply chain, but also the analysis of decisions that maximize supply chain profitability.

Discussion Questions

1. Which processes within each macro process are best suited to being enabled by IT? Which processes are least suited?
2. What are some advantages of the software as a service (SaaS) model? Why has it been successful in the CRM space?
3. Why is supply chain management software dominated by the ERP players, such as SAP and Oracle?
4. Identify a few examples of the availability of real-time information being used to improve supply chain performance.
5. Discuss why the high-tech industry has been the leader in adopting supply chain IT systems.

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