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5

Risk Mitigation Strategies

Increasing competition in the manufacturing industry is leading to mounting pressure to reduce supply chain costs. Companies are responding by pursuing strategies such as outsourcing, off-shoring, and lean manufacturing to retain market position or gain competitive advantage. Unfortunately, such cost-cutting measures are sometimes adopted at the expense of managing risk within the supply chain.

Indeed, current industry trends correlate directly to the rising risk levels in the supply chain. As off-shoring and globalization of manufacturing operations continue to grow, supply chains are geographically more diverse and therefore exposed to various types of natural and man-made disasters. Similarly, for lean manufacturers that focus on low inventory levels, one disaster can bring their businesses to a halt.

With the threat of megadisasters an increasing reality, industries need to establish risk mitigation measures that accurately reflect their levels of risk exposure. Unfortunately, while many companies are concerned with supply chain resiliency, only a small fraction of them actively and effectively manage risk.

The increase in the level of risk faced by the enterprise demands that supply chain executives systematically address extreme risks (such as port closings and natural disasters like hurricanes, epidemics, and earthquakes) as well as operational risks (such as forecast errors, sourcing problems, transportation breakdowns, and recall issues). Unfortunately, little can be done after a disaster has occurred. Companies therefore need to plan their supply chains so that they can better respond to both megadisasters and mundane operational problems.

One important human-made risk that has increased in the last few years is associated with fake products and counterfeits. Indeed, globalization has increased the risk that counterfeit and illegitimate prescription medicines will enter the supply chain, which poses health risks to the

patients who ingest the medications and leads to loss of revenue for the manufacturer. Similarly, counterfeit computer parts and electronic equipment are responsible for loss of revenue and may imperil product functioning and organizational operations.

This chapter examines various risks that are inherent in global supply chains and techniques that can mitigate these risks.

5.1 Many Sources of Risks

Global supply chains are exposed to some of the same risks that are faced by domestic supply chains and also experience additional risks that are associated with international trade. Figure 5.1 provides a nonexhaustive list of the various types of risks faced by global companies. Natural disasters, geopolitical events, epidemics, and terrorist attacks can shut down production lines because of lack of parts inventory. This happened to some auto manufacturers after the September 11, 2001, terrorist attacks on the United States.

Unfortunately, there is little experience to draw on to prepare for natural megadisasters such as hurricanes Katrina (2005) or Andrew (1992). Similarly, a viral epidemic like the 2003 SARS (severe acute respiratory syndrome) epidemic can shut down the flow of components and products from Asia to the rest of the world but is difficult to prepare

for because of lack of data. Following former Secretary of Defense Donald Rumsfeld, we refer to these types of risks as the *unknown-unknowns*: these risks are associated with scenarios where it is difficult to quantify the likelihood of occurrence.

At the other end of the spectrum shown in figure 5.1 are sources of risks such as supplier performance, forecast accuracy, and operational problems. These risks can be quantified and consequently are referred to as *known-unknowns*. For example, using historical data, a firm can characterize forecast error, mean time between machine failure, and supplier lead time performance.

Due to their nature, unknown-unknowns are difficult to control, while known-unknowns are more controllable. Between the two extremes are various types of risks that can be controlled to a certain extent. For example, risks associated with volatile fuel prices can be managed through long-term contracts, while fluctuating exchange rates can be managed through a variety of hedging strategies (discussed below).

Because organizations have different levels of control over the various sources of risks, they need to quantify the expected effects of these risks. *Expected impact* is defined as the product of (1) the likelihood that the risk will materialize and (2) the risk's potential direct effect on business—measured, for instance, by its effect on revenue or profit.

For example, for a company that sources key components from China, political instability in that country could be highly damaging. Because the likelihood of political problems and instability in China is low, the expected impact on the company is medium. By contrast, changes in commodity prices would have a relatively high expected impact. This is true since volatility in commodity prices is high and hence the likelihood of a price change in an unfavorable direction is high. If this happens, the impact on procurement costs can be high. Therefore high expected impact.

The two dimensions—the ability to control each source of risk and its expected impact—motivate the risk assessment framework depicted in figure 5.2. Controllable risk sources with high expected impact can and must be managed effectively. More challenging but equally important is developing risk mitigation strategies for the uncontrollable sources of risks that have high expected impact. Controlled or uncontrollable, management must map out the firm's risk portfolio in a similar fashion to what is done in our risk assessment framework so that gaps and challenges in the company's risk management strategies can be identified.



Figure 5.1
Risk sources and their characteristics

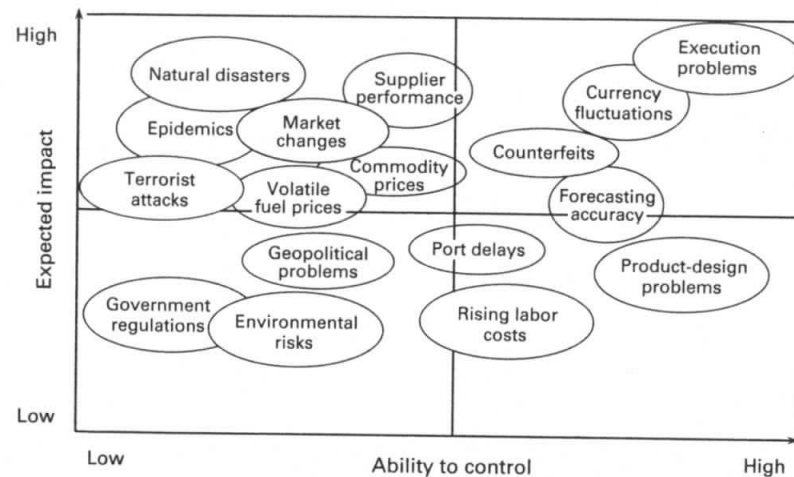


Figure 5.2
The risk assessment framework: Ability to control versus expected impact

A deeper review of the risk assessment framework suggests that management needs to develop risk mitigation strategies that depend on expected impact on business performance. This implies that business objectives and performance need to be matched with risk management strategies. The most effective way to achieve this is to follow this chapter's first rule:

Rule 5.1 *Integrate risks into operational and business decisions.*

Put differently, risk management is not an independent function in the organization but rather must be embedded in the firm's decision-making process. Production sourcing decisions, for example, should take into account at the design stage the expected effect of supply disruption on business performance. This approach calls for an organizational culture that fosters risk assessment and risk management as part of day-to-day decision making.

Example 5.1

CEMEX, one of Mexico's largest companies, specializes in building materials and operates in more than thirty countries. Competing in one of the world's toughest markets, CEMEX faces multiple layers of risks—operational risks (including price and demand risks), market risks

Example 5.1 (continued)

(including market-access and environmental-regulation risks), and global risks (including exchange-rate and energy-price risks). Two themes characterize CEMEX's risk management strategy. First, embracing rather than avoiding specific kinds of risks has become a core competence. For example, the firm pools capacity through spot trading to reduce commodity-price risk and increase value by better matching supply and demand. Second, risk management is so embedded in the company's cultural and organizational fabric that it is barely noticeable as a distinct management function at either the strategic or tactical level. For instance, strategically, the firm integrates risks management in its planning for production capacity and sourcing decisions, and operationally, it reduces risk by actively trading cement across markets. The result is that CEMEX matches or beats global industry standards in managing risks inherent in cement and concrete production and distribution, despite its considerable exposure to multiple layers of risks, especially in emerging markets.¹

So what methods can a (global) firm apply to mitigate natural and man-made risks? The next two sections consider strategies for dealing with unknown-unknowns (section 5.2) and for dealing with intermediate risks, that is those that are closer to the known-unknown end of the risk spectrum (section 5.3).

5.2 Managing the Unknown-Unknown

Are there any strategies at all that the firm can use to mitigate unknown-unknown risks? Unfortunately, these types of risks may create a mega-disaster that wipes out years of profit and may even force a company to exit a certain region or a specific market.

This section presents three methods for managing supply chain risks and, in particular, for managing the unknown-unknown. They are (1) invest in capacity redundancy, (2) increase velocity in sensing and responding, and (3) create a flexible supply chain community. A company that uses these methods effectively will have a *resilient supply chain* that allows it to recover from misfortune. Each method focuses on a different supply chain dimension. Capacity redundancy needs to be built at the design stage, speed in sensing and responding requires accurate and timely information, and a flexible supply chain community requires

partners that embrace flexibility, work toward the same objectives, and benefit from the financial gains.

Capacity Redundancy

A key challenge in risk management is to design the supply chain so that it can effectively respond to unforeseen events (the unknown-unknown) without significantly increasing costs. This can be done through careful analysis of supply chain cost trade-offs so that the appropriate level of redundancy is built into the supply chain.

Example 5.2

In 2001, a United States-based consumer packaged-goods company had a global supply chain with about forty manufacturing facilities all over the world. Demand for its products (household goods) was spread over many countries. The company grew organically and through acquisitions. Management realized that it was time to rationalize its manufacturing network and close nonproductive manufacturing facilities. Initial analysis indicated that the firm could reduce costs by about \$40 million a year by shutting down seventeen of its existing manufacturing facilities and leaving twenty-three plants operating, while still satisfying market demand all over the world.

Unfortunately, this new lean supply chain design suffered from two important weaknesses. First, the new design left no plant in North America or Europe, thus creating long and variable supply lead times to key markets. Such lead times require a significant increase in inventory levels. More important, the remaining manufacturing facilities in Asia and Latin America were fully utilized, so any disruption of supply from these countries—for instance, from epidemics or geopolitical problems—would make it impossible to satisfy demand from many market areas. So how can supply chain design take into account sources of risk such as epidemics or geopolitical problems that are difficult to quantify?

The approach that this firm took was to analyze the cost trade-offs. These trade-offs are illustrated in figure 5.3, where the horizontal coordinate represents the number of plants that remain open while the vertical coordinate depicts the various cost components—including variable production, fixed, transportation, duty, and inventory costs. The top line is the total cost—the sum of various cost components. As you can see, closing seventeen plants and leaving twenty-three open will minimize supply chain costs. However, the total cost function is quite flat around

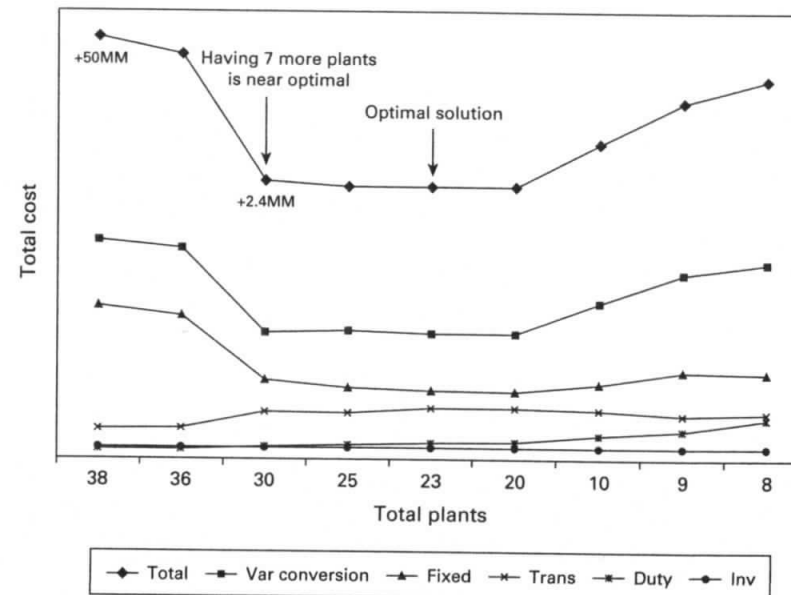


Figure 5.3
Cost trade-offs in supply chain design

Example 5.2 (continued)

the optimal strategy. Indeed, increasing the number of open plants from twenty-three to thirty facilities will increase total supply chain cost by less than \$2.5 million and increase redundancy significantly. Thus, even though the risks associated with epidemics or geopolitical problems cannot be quantified, companies can prepare the supply chain for supply disruptions by investing in redundancy without significantly increasing supply chain costs.

The example above illustrates an important characteristic of total supply chain costs that can be used to build redundancy and mitigate risks without increasing costs:

Rule 5.2 Supply chain cost is always flat around the optimal strategy.

This implies that many supply chain strategies are close in total supply chain cost to the low-cost strategy but some are more effective than

others from a risk mitigation point of view. Taking advantage of this property allows the firm to find the right balance between seemingly conflicting objectives—cost reduction and risk management.

The same property can be applied when the focus is on reducing carbon footprint. If environmental regulations such as cap-and-trade are considered, the firm can take advantage of rule 5.2 and choose a strategy whose cost is close to the optimal and its carbon footprint does not violate the carbon cap. This and other green strategies are analyzed in chapter 11, section 11.2.

Speed in Sensing and Responding

The following case illustrates how speed in sensing and responding can help the firm overcome unexpected supply problems. It also illustrates how failure to sense and therefore respond to changes in the supply chain can force a company to exit a specific market.

Example 5.3

In 2000, the Philips Semiconductor factory in Albuquerque, New Mexico, produced several types of radio frequency chips used in mobile telephones. Major customers included original equipment manufacturers such as Ericsson and Nokia. On Friday, March 17, 2000, at 8:00 p.m., lightning struck the Philips plant. The fire, smoke, and water used during the fire exhaustion destroyed or contaminated almost all the silicon stock in the factory, and the plant was shut down for months.

Three days after the fire, Nokia detected delays in incoming orders from the Albuquerque plant. In the initial contacts, Philips reported that it expected the plant to be shut for only one week. Fearing the worst, Nokia decided to send engineers to New Mexico to evaluate the damage. When the engineers were not allowed access to the plant, Nokia raised red flags and increased the frequency of monitoring incoming orders from the plant from weekly to daily. On March 31, two weeks after the fire, Philips confirmed to Nokia that months of orders would be disrupted.

Nokia's response to the news was decisive. The company changed product design so that it could use chips from other suppliers that committed to a five-day lead time. Unfortunately, this was not enough. One of the five components provided by Philips was impossible to source from other suppliers. So Nokia convinced Philips to provide this component from two of Philips's factories in China and the Netherlands.

Ericsson's experience was quite different. The news took four weeks to reach upper management, even though Philips informed Ericsson of

Example 5.3

(continued)

the fire three days after the incident. It took Ericsson five weeks to realize the severity of the situation. By that time, the alternative supply of chips was already taken by Nokia. The impact on Ericsson was devastating. Nearly \$400 million in potential sales was lost, and only part of the loss was covered by insurance. This, together with other problems, such as component shortages, the wrong product mix, and marketing problems—caused Ericsson Cell Phone Division to suffer a \$1.68 billion loss in 2000 and forced the company to exit the cell-phone market.²

This case can be put in perspective by reviewing Nokia and Ericsson's strategies prior to 2000. For many years, Nokia focused on modular product architecture, a strategy that provides supply chain flexibility through product design (see chapter 9). Because Ericsson's strategy was all about cost reduction, it adopted a single sourcing strategy in the 1990s—eliminating backup suppliers in an effort to reduce costs and streamline the supply chain.³

The implications are clear: supply chain cost reduction cannot justify a business strategy that does not maintain any degree of flexibility.

Rule 5.3 *Invest now, or pay later: firms need to invest in flexibility, or they will pay the price later.*

A Flexible Supply Chain Community

Ensuring a flexible supply chain community is the most difficult risk management method to implement effectively. It requires all supply chain partners to share the same culture, work toward the same objectives, and benefit from financial gains. It creates a community of supply chain partners that morph and reorganize to react better to sudden crises. The next example illustrates the effectiveness of a flexible supply chain community.

Example 5.4

In 1997, Aisin Seiki was the sole supplier of 98 percent of the brake-fluid proportioning valves (P-valves) used by Toyota Japan. P-valves are inexpensive (about \$7 each) but important in the assembly of any car. A supply interruption would shut down the Toyota production line. On Saturday,

Example 5.4 (continued)

February 1, 1997, a fire stopped production at Aisin Seiki's main factory in the industrial area of Kariya, where other Toyota providers are located. Initial evaluation of the damage estimated that it would take two weeks to restart production and six months for complete recovery.⁴

The situation was critical. Toyota was facing a season of great demand, and plants were operating at full capacity, producing close to 15,500 vehicles per day. Toyota's production system followed a just-in-time principle that stocked two to three days of inventory at a time, giving its plants a margin of only a few days before they would have to come to a complete stop.

Immediately after the fire, Toyota and its suppliers initiated a recovery effort to restructure the entire supply chain of P-valves. Blueprints of the valves were distributed to all Toyota suppliers, and engineers from Aisin Seiki and Toyota were relocated to suppliers' facilities and other surrounding companies such as Brother—a manufacturer of printers and

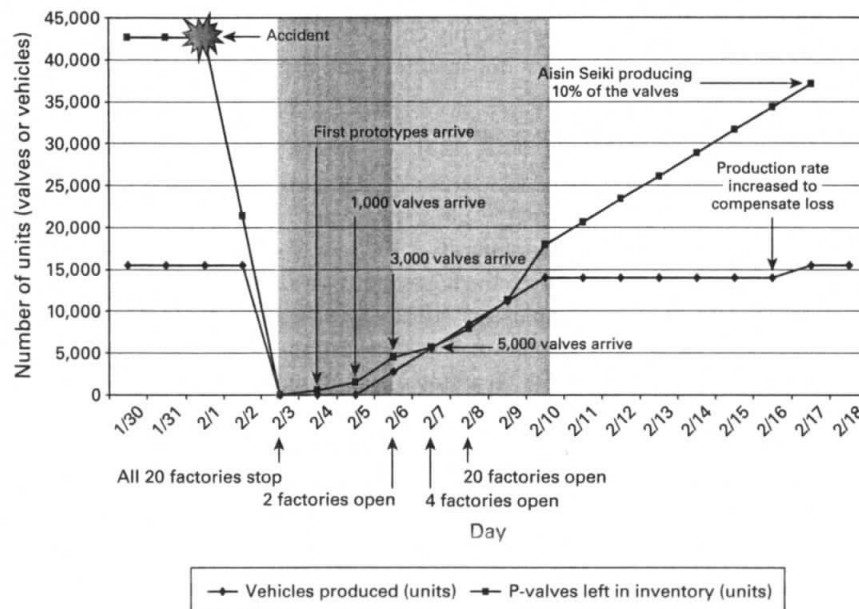


Figure 5.4
Vehicle production and P-valve inventory levels

Example 5.4 (continued)

sewing machines. Existing machinery was adapted to build valves according to Aisin Seiki and Toyota's specifications, and new machinery was acquired in the spot market. "Within days, firms with little experience with P-valves were manufacturing and delivering parts to Aisin, where they were assembled and inspected before shipment to Toyota."⁵ All and all, about 200 of Toyota's suppliers collaborated in the effort to minimize the impact of the Aisin Seiki fire and help the Toyota production line to recover as soon as possible.⁶

Figure 5.4 depicts the evolution of the production and inventories of valves and vehicles during the crisis. Factories came to a complete stop for three days, and full production was restored in less than one week. The accident initially cost Aisin Seiki 7.8 billion yen (\$65 million) and cost Toyota 160 billion yen (\$1.3 billion).⁷ However, it is estimated that the damage was reduced to 30 billion yen (\$250 million) with extra shifts and overtime.⁸ In addition, Toyota issued a \$100 million token of appreciation to its providers as a gift for their collaboration.

This example illustrates how Toyota's suppliers self-organized to address a sudden disruption in the supply of a key component. However, it raises three important questions. Does a single sourcing strategy make sense for such a key component? Even if a single sourcing strategy is appropriate, shouldn't Toyota carry large amounts of inventory for such a low-cost but key component? Finally, what underlying mechanisms in Toyota's supply chain help the firm quickly recover from a sudden supply disruption?

According to Kiyoshi Kinoshita, Toyota's general manager of production control, single sourcing and holding almost no inventory were calculated risks.⁹ Toyota's single sourcing allows Aisin Seiki to achieve economies of scale in P-valve production and offer high quality at very low cost to Toyota.¹⁰

T. Nishiguchi and A. Beaudet discuss the third question in detail.¹¹ They observe that key to understanding the ability of the supply chain to adapt to the new environment is the just-in-time (or lean) philosophy that Toyota and its suppliers followed almost religiously. The essence of just-in-time is to keep work-in-process (WIP) inventories at low levels to promote high quality and a quick identification of problems in the production line. In just-in-time, every worker has the authority to stop the line to correct any problem, which fosters the company's problem-solving capability (see chapter 8).¹²

These qualities were essential to the quick adaptability of Toyota's supply chain (example 5.4). As soon as Toyota identified that the Aisin Seiki fire was a problem, it stopped both its own production lines and the entire supply chain. This full stop of the chain forced supply chain partners to deal with the challenge.¹³

The Philips and Toyota case studies illustrate the supply-risk framework introduced in chapter 4, section 4.2. Radio frequency chips and P-valves are low-cost components whose disruption creates significant financial effects that need to be managed through inventory, dual sourcing, or flexibility. Product-design flexibility enabled Nokia to recover quickly from a supply disruption caused by the fire at Philips Semiconductor's factory, while process flexibility allowed Toyota to restart the supply of P-valves soon after a major disruption.

5.3 Managing Global Risks

Other risks faced by global supply chains include risks that, to a certain extent, can be quantified and controlled—the intermediate risks identified in figure 5.1. Bruce Kogut has suggested that a global supply chain can apply three strategies for addressing global risks—speculative, hedge, and flexible strategies.¹⁴

Speculative Strategies

Using *speculative strategies*, a company bets on a single scenario—with often spectacular results if the scenario is realized and dismal ones if it is not. For example, in the late 1970s and early 1980s, Japanese automakers bet that if they did all of their manufacturing in Japan, rising labor costs would be more than offset by exchange-rate benefits and rising productivity. For a while, these bets paid off, but then rising labor costs and unfavorable exchange rates began to hurt manufacturers, and it became necessary to build plants overseas. If it had remained favorable to do all the manufacturing in Japan, the Japanese manufacturers would have won the bet because building new facilities is time-consuming and expensive.

Hedge Strategies

Using *hedge strategies*, a company designs the supply chain in a way that any loss in part of the supply chain will be offset by a gain in another part. For example, Volkswagen operates plants in the United States, Brazil, Mexico, and Germany, which are important markets for

Volkswagen products. Depending on macroeconomic conditions, certain plants may be more profitable at various times than others. Hedge strategies, *by design*, are simultaneously successful in some locations and unsuccessful in others.

Flexible Strategies

When properly deployed, flexible *strategies* enable a company to take advantage of different scenarios. Typically, flexible supply chains are designed with *dual sourcing* and *redundant manufacturing capacity* in different countries. In addition, factories are designed to be flexible so that products can be moved at minimal cost from region to region as economic conditions demand (see chapter 7 for more on achieving flexibility through system design).

Example 5.5

A manufacturer in the apparel industry has a global network with six plants—in the United States (Florida), China, France, Mexico, Philippine, and Poland. Each plant is dedicated to one product family, and manufacturing capacity is designed so that line utilization is 90 percent based on projected demand. The firm sells its products all over the world in more than 100 different markets.

As is typical in the apparel industry, production sourcing decisions were made in the late 1990s and have not changed in the last ten years. This strategy focused on reducing manufacturing costs by employing a dedicated production strategy: each plant was responsible for one product family. Indeed, the high volume product family (accounting for about 20 percent of total demand) was produced in China (at a low-cost plant), while the low-volume product family (representing about 14 percent of demand) was produced in France (at a high cost plant).

This strategy worked well for quite a while. Recently, however, major retailers have been under a lot of pressure to reduce costs. This pressure emerged at a time when labor costs in developing countries have increased significantly. Some analysts estimate that in China, for example, labor costs in the manufacturing sector increased between 2003 and 2008 by a staggering 140 percent. Slowly but surely, a production sourcing strategy that worked well five years earlier had become ineffective. More confusing was the challenge to estimate where labor costs are heading and how much more expensive ocean transportation would become with highly volatile oil prices. Something needed to be done, but no one was sure what to do.

Example 5.5 (continued)

The planning team charged with the challenge recognized that any new strategy must take into account wage and productivity differences among the six countries. These data are presented in figure 5.5 which shows average hourly wage and gross domestic product per employed person for each country for the last fifteen or so years. Wages in France have increased relative to the United States, while productivity in France relative to the United States has decreased. China's productivity has increased in the last few years, and it is now more productive than the Philippines, while Poland is more productive but more expensive than Mexico.

To capture differences in wages and productivity for the six manufacturing locations, an index was created to compare expected per-unit costs of production in each country. The index uses the United States as a base level of 100. Table 5.1 shows that France is the most expensive labor-cost country and that China is the least expensive country. But the United States is only four times more expensive than China, while Mexico and Poland are less than twice more expensive than China. This is counter to figures typically cited by popular media suggesting that U.S. labor cost is at least ten times more expensive than labor cost in China. Combining wage and productivity shows a much smaller gap in manufacturing costs among countries such as Poland, Mexico, and China.

When the team began to analyze various options, investing in more capacity in low-cost countries was not one of them because of the increase in labor cost and the capital required. Outsourcing was not an option either. But flexibility was a real and attractive possibility since it

Table 5.1
Per-unit labor costs based on wage and productivity

Country	Cost per unit index
France	137
United States	100
Poland	53
China	27
Philippines	42
Mexico	41

Example 5.5 (continued)

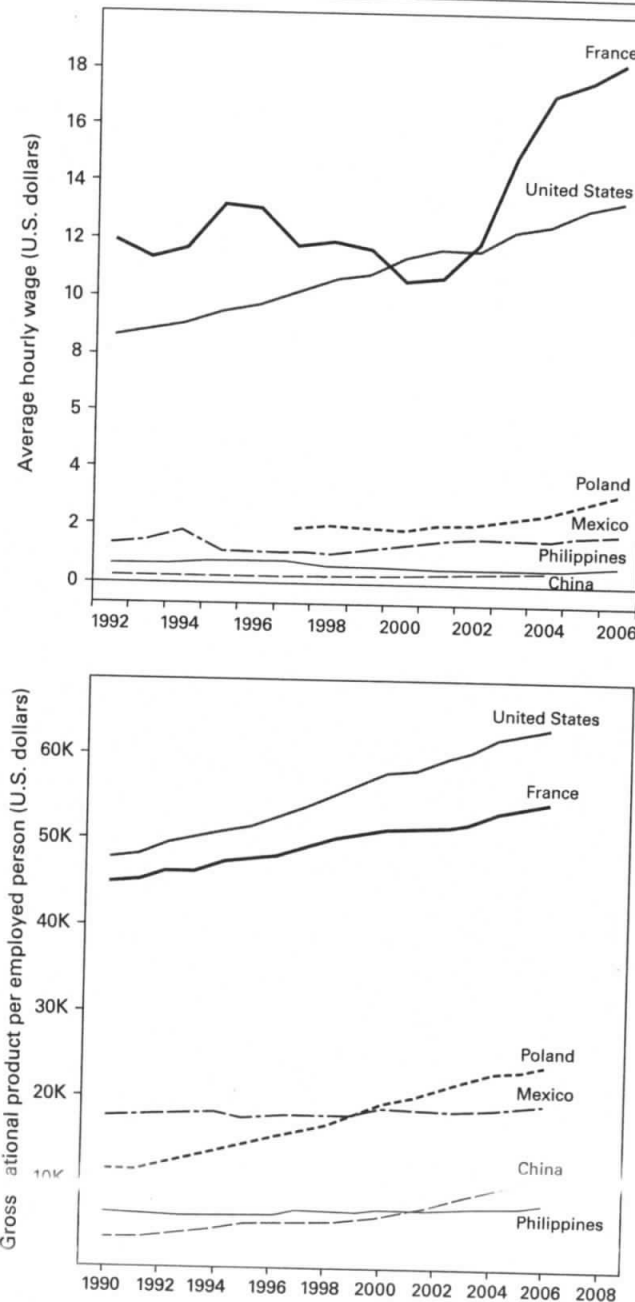


Figure 5.5
Wage and productivity analysis

Example 5.5 (continued)

does not require significant capital, it relies on available resources, and it provides a mitigation strategy against volatility in labor costs, oil price, and demand (see chapters 7 and 10). But how much flexibility was required and where to invest in flexibility were open for debate.

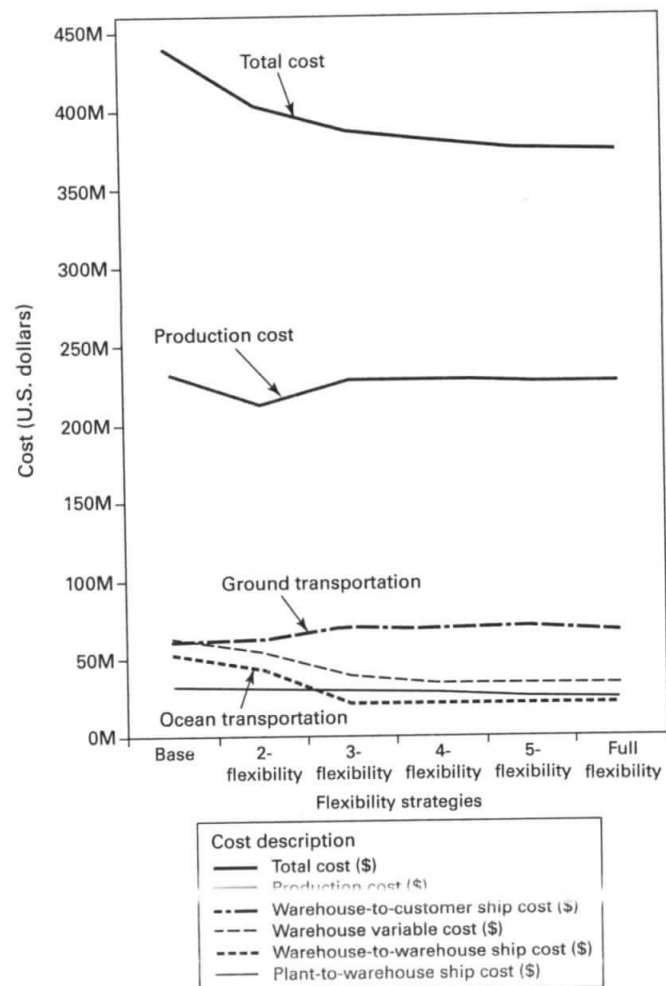


Figure 5.6
Cost comparison of six flexibility strategies

Example 5.5 (continued)

To address these issues and to estimate the benefits of investing in flexibility in this global network, the team analyzed six different system design strategies:

- Base case Each plant focuses on a single product family.
- 2-flexibility Each plant can manufacture up to two product families.
- 3-flexibility Each plant can manufacture up to three product families.
- 4-flexibility Each plant can manufacture up to four product families.
- 5-flexibility Each plant can manufacture up to five product families.
- Full flexibility Each plant can manufacture all six product families.

Figure 5.6 illustrates the ways that the various strategies affect each of the relevant supply chain costs. Investing in more flexibility reduces ocean transportation costs and increases ground transportation costs because more demand is served from local plants. Manufacturing costs first decrease and then increase as the firm invests in more flexibility. This is to be expected since investing in 2-flexibility is initially going to move production away from France and thus cut production costs. As the firm invests in more flexibility, manufacturing costs increase due to the loss of economies of scale. The net effect is that full flexibility reduces total supply chain costs by 15 percent. Note that investing in 2-flexibility provides the supply chain with 60 percent of the cost savings of full flexibility—that is, 2-flexibility reduces supply chain costs relative to the baseline by 9 percent.

Additional analysis was undertaken as wages rose in China and Poland and exchange rates fluctuated. The objective was to determine how well the new design, 2-flexibility, could respond to market changes. For example, the projected increases in labor costs for 2010 were about 20 percent in China and 10 percent in Poland. As expected, 2-flexibility outperformed the dedicated manufacturing strategy in this scenario, reducing the increase in costs due to rising labor costs by 15 percent.

The example thus illustrates three important observations that are often overlooked by management. First, operational decisions need to be frequently revisited, reevaluated, or simply changed. In a fast-clock-speed environment, decisions that were attractive and effective a few years ago may not be appropriate today. Second, production sourcing decisions

should not be based purely on material or labor costs. Productivity plays an important role in the analysis. But even this is not enough! Senior management should consider the effects of various sourcing decisions on total supply chain costs, including transportation and inventory. Finally, volatility in oil prices, exchange rates, and customer demand together with the uncertainty about labor costs supports investing in at least a small amount of flexibility (more on this in chapter 10).

5.4 Resiliency Scorecard

A company that cannot embed risk management as part of its cultural and organizational fabric cannot manage risk effectively. One element in changing culture, driving collaboration, and achieving a truly resilient supply chain is the introduction of a companywide resiliency scorecard. The objective of such a scorecard is to identify gaps in the company's risk management strategies by analyzing the current state of the company's risk mitigation processes and comparing them to its goals.

Cisco is a case in point. Cisco—the leading supplier of networking equipment and network-management solutions for the Internet—provides a broad range of products, mostly configured-to-order, through a large number of manufacturing partners. With almost all of its manufacturing activities outsourced, the firm faces significant risks.¹⁵ This includes risks associated with manufacturing sites, suppliers, components, and test equipment. To address these challenges, Cisco's *resiliency scorecard* includes four categories—manufacturing resiliency, supplier resiliency, component resiliency, and test equipment resiliency.¹⁶

The resiliency scorecard predicts areas with potential risk and therefore helps the firm to take corrective actions depending on the source of risk. For example, manufacturing resiliency measures the existence of alternate sites, qualified manufacturers, and delivery response times when a disruption occurs.

Similarly, insights obtained from analyzing a supplier's behavior—using financial information about public companies and correlating the data with supplier performance such as lead time or service level—allow the firm to develop a *supplier score*. A supplier score is much like a credit score applied by the financial industry to estimate the likelihood that an individual consumer will default on future payments. In operations, a supplier score rates suppliers according to the likelihood that they will default on future commitments—such as on time delivery and quality—because of financial problems or labor disruptions. Such scoring systems

may motivate the buyer to purchase more inventory in advance of a (projected) supplier bankruptcy, to develop a dual sourcing strategy for all high risk suppliers, or to search for an alternate supplier.

In component resiliency, only those components that significantly affect revenue are considered. Such components can be high cost components but also can be low-cost components (such as P-valves) whose shortage will disrupt the supply chain. In this case, resiliency measures the percentage of standard components, nonstandard parts with substitutable components, single-sourced components, and sole-sourced components.¹⁷ Sole-sourced components are the most risky as they represent parts that are available from only one supplier. Single-sourced components have multiple suppliers, but the firm has selected, for various reasons, only a single supplier.

Cisco updates the resiliency scorecard for products already in the market on a quarterly basis. For new products, Cisco updates the scorecard at key milestones during the product-development lifecycle.

An effective risk management strategy does not end with a scorecard. It must be complemented with teams that help tier 1 suppliers improve their operations and reduce risk with their own components, manufacturing sites, and suppliers.

5.5 Coping with Counterfeit

Globalization has increased the risk that counterfeit components and products will enter the supply chain—with severe consequences to the economy, public health and safety, and national security. For example, illicit drugs pose health risks to the patients who ingest the medications and loss of revenue to the manufacturer. Similarly, counterfeits of electronic and computer components used in warplanes, ships, and communication networks can cause fatalities in military operations.¹⁸ Finally, fake clothing, fashion, and sportswear products cause severe losses for the consumer-product industry.

Despite efforts by various companies, industry associations, and the federal government, the problem is growing. For example, figure 5.7 shows a significant increase in counterfeit drugs reported by the U.S. Food and Drug Administration's Office of Criminal Investigations (OCI) from 1997 to 2008. No one knows for sure, but experts estimate that up to 15 percent of all drugs sold are counterfeit, and in parts of Africa and Asia this figure exceeds 50 percent.¹⁹ More important, counterfeit drugs can be dangerous:

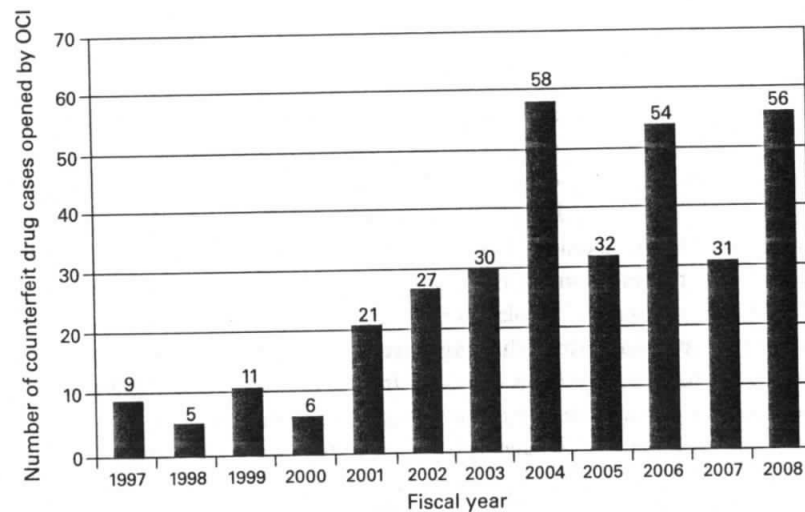


Figure 5.7

Counterfeit drug cases reported by the U.S. Food and Drug Administration's Office of Criminal Investigations. Source: U.S. Food and Drug Administration, <http://www.fda.gov>.

- In March 2010, thieves stole \$75 million worth of prescription medicines from Eli Lilly's warehouse in Connecticut. Beyond the financial loss, the fear is that the drugs will reach consumers after being stored in clandestine warehouses, reducing their effectiveness, or worse, their content will be diluted with ineffective ingredient.
- In June 2009, the government of Nigeria announced that it foiled an attempt to import fake antimalaria tablets that were produced in China but labeled "Made in India." If the drugs were not intercepted by the Nigerian government, the lives of 642,000 adults would have been put at risk.²⁰
- In 2006, more than 100 patients in Panama were killed by medicines manufactured with counterfeit glycerin.²¹
- In Haiti, Nigeria, Bangladesh, India, and Argentina, more than 500 patients, predominantly children, are known to have died from consumption of fake paracetamol syrup.
- In the 1980s, 1 million counterfeit birth control pills were distributed to unsuspecting women, resulting in unwanted pregnancies and irregular bleeding.²³

Counterfeiting is big business. The U.S. government currently estimates that counterfeits account for more than \$1 trillion in annual business. In the electronics industry alone, experts estimate counterfeits cost at \$100 billion to \$200 billion annually, or nearly 10 percent of all electronic equipment sold worldwide.²⁴

Fighting counterfeits requires a combination of technology and processes, but the specifics vary from industry to industry and even product to product. Before we identify the appropriate strategy, it is important to start with a definition of "counterfeit." According to *Wikipedia's* definition (slightly modified here), *counterfeit* means "an imitation made with the intent to misrepresent its content, origin, or history." For example, in the electronics industry, a chip falsely identified as having been made by Xicor, a unit of Intersil, was discovered in the flight computer of an F-15 fighter jet at Robin Air Force base in Warner Robins, Georgia.²⁵

In the research for an article titled "Dangerous Fakes" published in October 2008,²⁶ *Business Week* "tracked counterfeit military components used by gear made by BAE Systems to traders in Shenzhen, China. The traders typically obtain supplies from recycled-chip emporiums such as the Guiyu Electronics Market outside the city of Shantou in southeastern China. The garbage-strewn streets of Guiyu reek of burning plastic as workers in back rooms and open yards strip chips from old PC circuit boards. The components, typically less than an inch long, are cleaned in the nearby Lianjiang River and then sold from the cramped premises of businesses such as Jinlong Electronics Trade Center."²⁷

In the pharmaceutical industry, "counterfeit medications are deliberately and fraudulently mislabeled with respect to identity or source: their quality is unpredictable as they may contain the wrong amount of active ingredients, wrong ingredients or no active ingredients at all. In all cases counterfeit medicines are manufactured in clandestine laboratories with no possibility of control."²⁸

There are various ways to combat counterfeits:

- **Supplier selection** As indicated in *Business Week*, the core of the problem in the electronics industry is that original equipment manufacturers purchase components from brokers and traders that are not able to distinguish fake from real parts. This suggests that buying directly from contract manufacturers or authorized distributors is an important step in the fight against counterfeits. If brokers are needed, the firm may be advised (or required) to test each component.³⁰

• *Marking* Marking a product or a package in a way that is covert, is difficult to replicate, and yet allows quick and inexpensive identification of genuine products can help prevent mistakes.³¹ Examples include holographic labels and materials with upconverting properties such as phosphors that emit visible light when exposed to certain frequencies of infrared lights.³² In all cases, individual products or packages are not uniquely encoded, but the authentication of a genuine product is possible.

• *Encoding* Saleable units, cartons, pallets, and other packaging configurations can be encoded using technologies such as radio frequency identification (RFID) or two-dimensional (2D) barcode (sometimes referred to as *2D data matrix*). RFID is a technology that deploys tags emitting radio signals and devices (called *readers*) that pick up the signals. The tags can be active or passive—that is, they either broadcast information or respond when queried by a reader. They can be read-only or read/write and can be one-time or reusable. They can be used to read an electronic product code (EPC)—a unique number that identifies a specific item in the supply chain—and to record information for directing workflow along an assembly line or for monitoring and recording environmental changes. An essential component of the widespread acceptance of RFID is the EPCglobal network, which allows password-protected access to the Internet of RFID data anywhere in the supply chain. A 2D barcode is a barcode that uses two dimensions (vertical and horizontal) to store data rather than the linear barcode that only uses one dimension (horizontal). This allows more data to be stored and is more difficult than a one-dimensional barcode to replicate.

• *Taggants* Coined by Microtrace, the word *taggant* refers to an invisible material with a complex molecular structure that generates a unique fingerprint. Chemical taggants omit light that can be detected by scanners. These chemicals can be imbedded in various materials—such as labels, packaging, film, paper, and plastic—and provide a high level of security. Even when an adversary knows about the existence of taggants, it is difficult to decode the complex fingerprint produced by the chemicals. Originally developed to provide high levels of security and track-and-trace capabilities for explosives, taggants have been applied in other industries—like the pharmaceutical industry—and are incorporated into packaging resins, films, and inks for drug protection.³³ Its main limitation is the ability to scale because of the need for contact between the product and the reader.

A rigorous process for selecting and collaborating with suppliers is an important element in any anticounterfeiting strategy. But which anti-

counterfeiting technology should be deployed? Because each technology has its own advantages and disadvantages, companies need a framework to help them decide whether they should use marking, encoding, or taggants. These three technologies can be evaluated according to the following criteria:

• *Public health and safety* Taggants are the most secure technology, with unique product encoding that is difficult to break or replicate. RFID and 2D barcode are the next safest, although only sophisticated adversaries will be able to break into a supply chain protected with these technologies. The least security protection is provided by marking.

• *Cost and implementation time* RFID is the most expensive technology and has the longest implementation time. 2D barcodes and taggants require an investment in readers, 2D barcodes require tags, and taggants require chemicals and equipment.

• *Track-and-trace capability* Technologies that allow encoding have track-and-trace capability for identifying each product. This is true for taggants, RFID, and 2D barcodes. Track-and-trace provides records of the path that each product takes, not only within a company's supply chain but also between trading partners.

• *Scalability* Scalability is where RFID has the biggest advantage. Because there is no need for line of sight between readers and tags, individual products can be identified while still on a pallet. Taggants and 2D barcodes require pallets and boxes to be broken if individual products need to be identified at each entry point—warehouse, distribution center, and retail outlet. In addition, 2D barcodes are easier to scale than taggants since taggants need contact between the reader and the product. Similarly, taggants are customized for individual products, which explains the high level of security they provide but unfortunately this makes the technology difficult to scale.

• *Logistics efficiencies* Any technology that provides track-and-trace capabilities and scalability provides logistics efficiencies, since the firm can monitor in almost real time its inventory levels at different locations and can use this information to make manufacturing, distribution, or pricing decisions. This implies that RFID is highly attractive from this point of view, followed by 2D barcodes.

Table 5.2 compares the various anticounterfeiting technologies. Note the significant difference between 2D barcode and RFID. RFID can provide significant anticounterfeiting capability while the 2D barcode has a limited ability to do so. However, the cost difference between the two is huge. To put this in perspective, a recent MIT study suggests that

Table 5.2
Comparison of anticounterfeiting technology

	Encoding			
	Marking	2D barcode	RFID	Taggants
Health and safety	Low	Medium	High	High
Cost	Low	Low	High	Medium
Implementation time	Short	Short	Long	Intermediate
Track-and-trace	Not capable	Capable	Capable	Capable
Scalability	Low	Low	High	Low
Logistics efficiency	Does not exist	Medium	High	Low

for applications in the pharmaceutical industry, the cost of RFID tags needs to drop down to 5 cents per unit to justify using the technology at the stock keeping unit (SKU) level.³⁴

The advantages and disadvantages of the various technologies suggest that the appropriate approach to counterfeits depends on product, industry, and level of sophistication expected from an adversary.

The Pharmaceutical Industry

The pharmaceutical industry has been perhaps the first to respond in a systematic way to the challenges of counterfeits. Recent regulatory and legislative initiatives include the following:³⁵

- *U.S. states* A number of U.S. states have established pedigree requirements. California has led the way, and by 2015 the state will require an electronic pedigree (see below) at a sealable unit level from manufacturer all the way to pharmacist.
- *U.S. federal government* Congress is considering federal anticounterfeiting legislation.
- *International* The World Health Organization (WHO) has established an International Medical Products Anti-counterfeiting (Impact) Task Force whose mission is “to promote and strengthen international collaboration to combat counterfeit medical products.” In December 2000, the European Commission published its proposal on how to block falsified products from entering the legal supply chain of medical products.

A phased approach is needed for counterfeit protection in the pharmaceutical industry.³⁶ This phased approach has multiple objectives—to

provide near-term protection for patients, to enable the industry to assume a leadership position and help shape future regulations, to create a flexible and financially sound base on which to build systems that will meet future regulation, and finally, to create a sequence of investments that will retain value as well as build levels of protection.

In this phased approach, the firm adopts a near-term implementation of a basic system of 2D barcodes for validation and authentication. An *exit point*—for example, a hospital, pharmacy, or possibly patient—uses email, text messaging, or Web access to send an item-level serial number (the 2D barcode) to the manufacturer (the *entry point*) for validation and authentication. An automatic response lets the user know if the serial number was created by the manufacturer. This point-of-entry/point-of-exit validation system is basic, simple to implement, and does not involve or put requirements on other participants in the supply chain. It provides near-term patient protection, builds company capability, and establishes a leadership position for future regulatory discussions.

Example 5.6

Roche India is currently using a variant of this point-of-entry/point-of-exit validation system, and Phillip Morris International uses this fundamental concept to combat contraband cigarettes in Europe. In the case of Phillip Morris, law enforcement agencies, retailers, and consumers can authenticate packages of cigarettes. For this purpose, a twelve-digit unique barcode is printed on the cigarette pack. The code can be transmitted and verified using telephone, text message, email, and Web sites.³⁷ In the case of Roche India, every unit of sale has a sixteen-digit alphanumeric security code, and text messages or emails are used for authentication.³⁸

This basic validation system does not provide track-and-trace capability. As a result, it has some weaknesses and vulnerabilities, but it does provide a new, higher level of protection for patients. It also provides the foundation on which the track-and-trace feature can be built.

Adopting and implementing a point-of-entry/point-of-exit validation system is step 1 in a recommended phased approach. Implementing item-level encoding and providing validation at an exit point build important corporate capabilities and suggest solutions for the next steps. This step actively helps the industry shape its own future.

After regulations become clearer, the point-of-entry/point-of-exit system based on item-level encoding can be augmented to create and

send an ePedigree message. An *ePedigree* is defined as “a record in electronic form containing information regarding each transaction resulting in a change of ownership of a given dangerous drug, from sale by a manufacturer, through acquisition and sale by one or more wholesalers, manufacturers, or pharmacies, until final sale to a pharmacy or other person furnishing, administering, or dispensing the dangerous drugs. The pedigree shall be created and maintained in an interoperable electronic system, ensuring compatibility throughout all stages of distribution.”²⁹

In this phased approach for the pharmaceutical industry, the investment in encoding software and hardware required for step 1 retains its value. In this upgraded system, the pedigree is created by the manufacturer and then updated by the manufacturer when an item is shipped. The pedigree then is sequentially updated as the item moves through the supply chain and tracks changes of ownership or possession.

The Automotive Industry

The level of protection required for supplier products in the automotive industry is not as high as in the pharmaceutical industry, and no anticipated regulations are being developed to shape standards and requirements. This industry is characterized by low margins, high volume, global supply chains, and multiple suppliers.⁴⁰ Unfortunately, RFID tags are still too expensive to be used in this industry, certainly at the product level. In this case, a hybrid approach is appropriate, so 2D barcodes or taggants are applied at the product level, and RFID is employed at the pallet or container level. This provides scalability at the pallet or container level and better protection at the product level without significant increase in cost.

The Food Industry

The food industry was one of the first to generate an interest in risk mitigation strategies, mostly for food safety. Since 2005, the U.S. Food and Drug Administration has required certain food facilities to maintain records identifying the sources, recipients, and transporters of food products.⁴¹ The objective is to allow the FDA, manufacturers, and retailers to trace backward and forward food products throughout the food supply chain so that (1) the source of a compromised food article can be identified (the *backward tracing capability*) and (2) all food articles that emanate from the same source, are part of the same production lot, and possibly present a health threat can be identified (the *forward tracing capability*). Achieving such degree of protection requires the following:

- Using 2D barcodes, RFID, or taggants to encode at the carton or box level. Because of the margins and volume involved, the 2D barcode seems to be the most appropriate technology right now.
- Establishing unique standards across the industry or at least the product category, and
- Establishing shared databases so that the origin of a compromised product and the destinations of all products from the same production lot can be identified quickly.

Such unique standards and shared databases demand close collaboration among farmers, manufacturers, packers, distributors, and retailers. The industry is moving in that direction due to government regulations in the United States and Europe as well as early initiatives by manufacturers in Australia, New Zealand, and Europe.

5.6 Summary

There are many more man-made and natural sources of risks than those listed in this chapter. However, the principles presented here—including “Integrate risks into operational and business decisions” (rule 5.1), “Supply chain cost is always flat around the optimal strategy” (rule 5.2), “Invest now, or pay later: firms need to invest in flexibility, or they will pay the price later” (rule 5.3), and “Speed in sensing and responding”—are universal principles that can help companies mitigate many sources of risks, particularly the unknown-unknown. Of course, there are no guarantees that firms adopting these principles will always be able to overcome any source of risk, but following these principles significantly increase the likelihood of success.

Finally, information technology can provide track-and-trace capabilities for coping with counterfeits. But with IT investments accounting for a major portion of corporate expense, how should the organization set up priorities for its IT investments? How can the firm ensure that it is using its existing IT infrastructure effectively? Can IT provide a sustainable competitive advantage? These are the subjects of the next chapter.

Acknowledgments

Rule 5.2, “Supply chain cost is always flat around the optimal strategy,” is introduced and proved in an earlier work.⁴² Examples 5.3 and 5.4 were adapted with kind permission from Cela Diaz and other sources.⁴³ Example 5.5 is loosely based on my experiences with several companies.

The Eli Lilly story in section 5.5 is based on a recent op-ed article in the *New York Times*.⁴⁴

Notes

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6

Rethinking the Role of Information Technology

In 1979, Kmart was one of the leaders of the retail industry with 1,891 stores and an average revenue per store of \$7.25 million. At that time, Wal-Mart was a small niche retailer in the South with 229 stores and an average revenue per store of about half of that of Kmart stores. In ten years, Wal-Mart transformed itself and the retail industry, and in 1992, it had the highest sales per square foot, highest inventory turnover, and largest operating profit of any discount retailer.¹ How did Wal-Mart do it? The starting point was a relentless focus on satisfying customer needs. Wal-Mart's goal was simply to provide customers with access to goods when and where they want them and to develop a cost structure that enables competitive pricing.²

The key to achieving this goal was to make the way that the company manages its supply chain the centerpiece of its strategy.³ Two major components in Wal-Mart's competitive strategy were critical to its success. First, an enthusiastic application of a continuous replenishment strategy initially developed in partnership with Procter & Gamble. In this strategy, goods are continuously delivered to Wal-Mart's warehouses, from where they are dispatched to stores without ever sitting in inventory. Second, to facilitate the continuous-replenishment strategy, Wal-Mart was the first retailer to invest in a private satellite communications system that sends point-of-sale (POS) data to its distribution centers and vendors, allowing the company to have a clear picture of sales at all of its stores.

Fast forward to 2008, this innovative company now lags behind the competition in its information technology (IT) infrastructure. It is loaded with home-grown rudimentary technology that cannot match what its competitors, Target and Amazon, are able to extract from commercial applications. And the differences show. In 2008, Wal-Mart's operating margins (5.73 percent) were lower than Target's (6.51 percent).