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Managing Risk To Avoid Supply-Chain Breakdown

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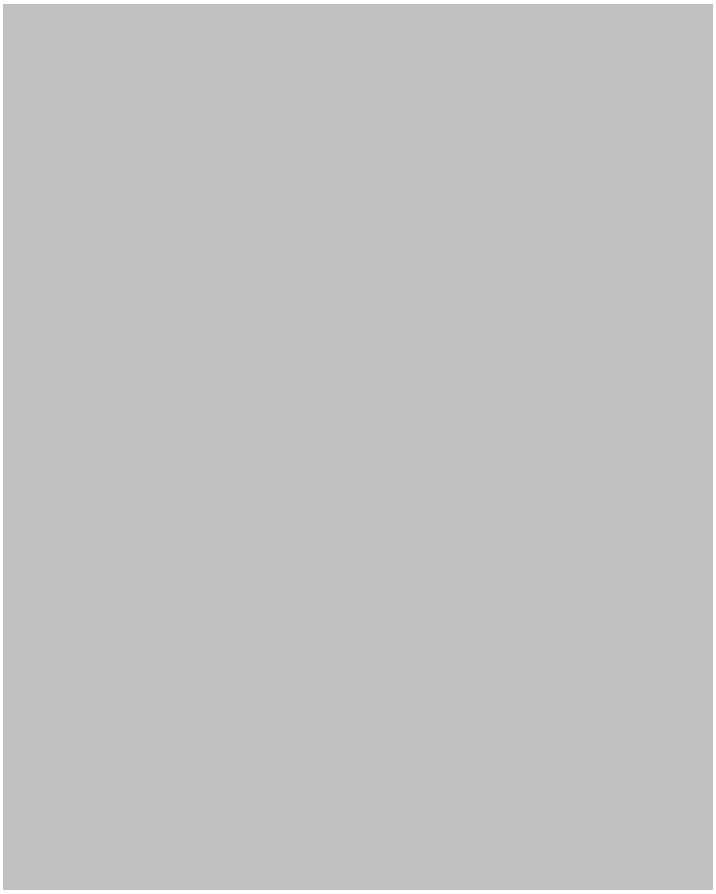
Managing Risk To Avoid **Supply-Chain Breakdown**



By understanding the variety and interconnectedness of supply-chain risks, managers can tailor balanced, effective risk-reduction strategies for their companies.

Sunil Chopra and ManMohan S. Sodhi

On March 17, 2000, lightning hit a power line in Albuquerque, New Mexico. The strike caused a massive surge in the surrounding electrical grid, which in turn started a fire at a local plant owned by Royal Philips Electronics, N.V., damaging millions of microchips. Scandinavian mobile-phone manufacturer Nokia Corp., a major customer of the plant, almost immediately began switching its chip orders to other Philips plants, as well as to other Japanese and American suppliers. Thanks to its multiple-supplier strategy and responsiveness, Nokia's production suffered little during the crisis.

In contrast, Telefon AB L.M. Ericsson, another mobile-phone customer of the Philips plant, employed a single-sourcing policy. As a result, when the Philips plant shut down after the fire, Ericsson had no other source of microchips, which disrupted production for months. Ultimately, Ericsson lost $400 million in sales.[1] (Ericsson has since implemented new processes and tools for preventing such scenarios.[2])

These two dramatically different outcomes from one event demonstrate the importance of proactively managing supply-chain risk. Supply-chain problems result from natural disasters, labor disputes, supplier bankruptcy, acts of war and terrorism, and other causes. They can seriously disrupt or delay material, information and cash flows, any of which can damage sales, increase costs — or both. Broadly categorized, potential supply-chain risks include delays, disruptions, forecast inaccuracies, systems breakdowns, intellectual property breaches, procurement failures, inventory problems and capacity issues. Each category has its own drivers (see "Supply-Chain Risks and Their Drivers," p. 54) and mitigation strategies (see "Assessing the Impact of Various Mitigation Strategies," p. 55).

How a company fares against such threats depends on the type of disruption and the organization's level of preparedness. To prevent the kind of heavy sales losses suffered by Ericsson after the Philips plant fire, managers must perform a delicate balancing act to keep inventory, capacity and other elements at appropriate levels across the entire supply chain in a dynamic, fast-changing environment. Dell, Toyota, Motorola and other leading manufacturers excel at identifying risks to their supply chains, and at creating powerful mitigation strategies that neutralize potentially negative effects. With a clear

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Supply-Chain Risks and Their Drivers

Before companies can devise effective means of reducing supply-chain risks, managers must first understand the universe of risk categories as well as the events and conditions that drive them. Then, armed with clear, specific knowledge about these crucial risks, companies can proceed to select and tailor mitigation strategies likely to be most effective. (See "Assessing the Impact of Various Mitigation Strategies.")

Category of Risk	Drivers of Risk
Disruptions	■ Natural disaster ■ Labor dispute ■ Supplier bankruptcy ■ War and terrorism ■ Dependency on a single source of supply as well as the capacity and responsiveness of alternative suppliers
Delays	■ High capacity utilization at supply source ■ Inflexibility of supply source ■ Poor quality or yield at supply source ■ Excessive handling due to border crossings or to change in transportation modes
Systems	■ Information infrastructure breakdown ■ System integration or extensive systems networking ■ E-commerce
Forecast	■ Inaccurate forecasts due to long lead times, seasonality, product variety, short life cycles, small customer base ■ "Bullwhip effect" or information distortion due to sales promotions, incentives, lack of supply-chain visibility and exaggeration of demand in times of product shortage
Intellectual Property	■ Vertical integration of supply chain ■ Global outsourcing and markets
Procurement	■ Exchange rate risk ■ Percentage of a key component or raw material procured from a single source ■ Industrywide capacity utilization ■ Long-term versus short-term contracts
Receivables	■ Number of customers ■ Financial strength of customers
Inventory	■ Rate of product obsolescence ■ Inventory holding cost ■ Product value ■ Demand and supply uncertainty
Capacity	■ Cost of capacity ■ Capacity flexibility

understanding of the types of supply-chain risks, managers in many types of industries can tailor effective risk-reduction approaches to their own companies.

A Variety of Risks

Managing supply-chain risk is difficult because individual risks are often interconnected. As a result, actions that mitigate one risk can end up exacerbating another. Consider a lean supply chain. While bare-bones inventory levels *decrease* the impact of overforecasting demand, they simultaneously *increase* the impact of a supply chain disruption. Similarly, actions taken by any company in the supply-chain can increase risk for any other participating company.

Supply-chain risks can become full-fledged supply-chain problems, causing unanticipated changes in flow due to disruptions or delays. Disruptions can be frequent or infrequent; short- or long-term; and cause problems for the affected organization(s), ranging from minor to serious. A simple delay along the chain may create a temporary risk, whereas a sole supplier holding up a manufacturer to force a price increase represents a long-term risk. A machine breakdown may have a relatively minor impact on a manufacturing company with redundant capacity, whereas a war that disrupts shipping lanes can have a major impact on a shipping company.

Most companies develop plans to protect against recurrent, low-impact risks in their supply chains. Many, however, all but ignore high-impact, low-likelihood risks. For instance, a supplier with quality problems represents a common, recurrent disruption. Without much effort, the customer can demand improvement or find a substitute. In contrast, in regions where earthquakes are rare, preparedness to prevent major disruption may be weak or uneven.

Leading companies deal with this range of supply-chain risks by holding reserves. Just as insurance companies hold cash reserves to meet claims, top manufacturers hold supply-chain reserves that include excess inventory, excess capacity and redundant suppliers. The big challenge for managers here: Mitigate risk by intelligently positioning and sizing supply-chain reserves without decreasing profits. So while stockpiling inventory may shield a company against delivery delays by suppliers, building reserves in an undisciplined fashion also drives up costs and hurts the bottom line. The managers' role here is akin to that

of a stock portfolio manager: Attain the highest achievable profits (reward) for varying levels of supply-chain risk and do so efficiently. (See "Choosing Supply-Chain Risk/Reward Trade-Offs," p. 56.) This means the manager must seek additional profits for any level of risk protection and preparedness or increase prevention and preparedness without reducing profits. Success at this task requires a good understanding of supply-chain risks and remedies, both broad and tailored to the manager's own company.

Delays Delays in material flows often occur when a supplier, through high utilization or another cause of inflexibility, cannot respond to changes in demand. Other culprits include poor-quality output at supplier plants (or at their suppliers' plants), high levels of handling or inspections during border crossings and changing transportation modes during shipping. If material-flow delays are frequent, however, companies can plan mitigation strategies based on historical information.

Organizations can avoid delays, or at least prepare for them, by appropriately and economically placing and sizing their capacity and inventory reserves. One simple solution is to maintain excess flexible capacity in existing plants. Toyota Motor Corp., for example, accomplishes this on its assembly lines by employing team leaders who can work on any station. Besides reducing the need for extra, station-specific workers to cover absences, the strategy also ensures that daily production goals are met, even when minor assembly-line problems occur.[3]

Another solution for delays is balancing capacity and inventory, depending on the cost of the products. For example, telecommunications equipment maker Cisco Systems Inc. has *capacity* to assemble higher-value items in the United States. This enables the company to respond quickly to orders from up-market domestic customers. In contrast, Cisco holds an *inventory* of lower-value, high-demand items produced in low-cost (but not very responsive) locations overseas. Thus, by matching approach to product value, Cisco reduces both supplier-delay risks and inventory costs.

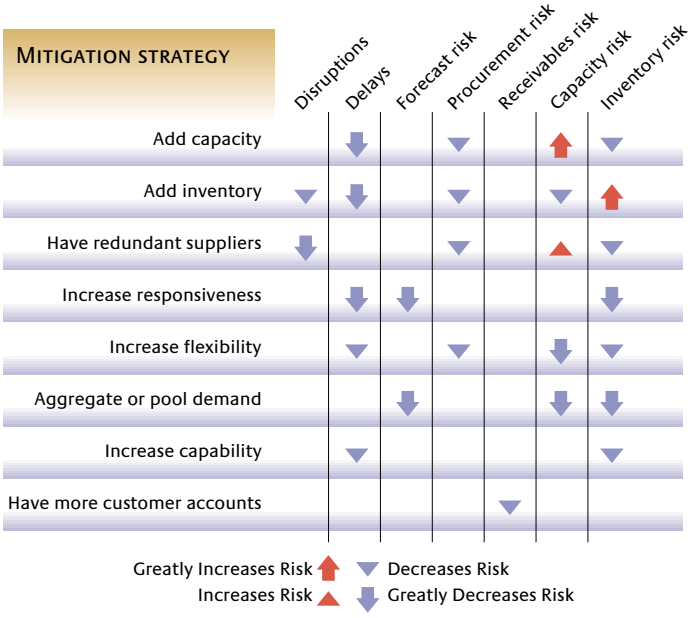
Yet another solution is to combine inventory with different transport modes. Dell Inc. holds very little inventory of high-value components in the United States. Instead, the personal computer manufacturer uses high-cost air transportation to deliver components from the Far East as needed. For less expensive components, however, Dell keeps some inventory that is shipped regularly at low cost to the United States. In this way Dell, minimizes delay-related risk as well as inventory-related costs.

Disruptions Disruptions to material flows anywhere in the supply chain are unpredictable and rare but often quite damaging. Examples abound of how natural disasters, labor strikes, fires and terrorism have halted the flow of materials. For instance, following a February 1997 fire at a parts factory owned by Japanese manufacturer Aisin Seiki Co. Ltd., a key supplier for Toyota, the auto giant was forced to temporarily shut down production at most of its Japanese plants.[4] The negative impact can be international: The 1994 Kobe earthquake in Japan, to cite just one case, left California-based sound card maker Kelly Micro Systems and many other small companies without any supply of parts.[5] The California dockworkers strike in 2002 produced shortages of high-demand retail items.[6] The 2001 bankruptcy of U.K.-based UPF-Thompson, sole chassis supplier to Ford Motor Co.'s Land Rover unit, caused major problems for the automaker.[7] Immediately after the attacks of September 11, 2001, U.S. auto manufacturers ran short of parts because transport trucks had been delayed at the Canadian border.[8] In addition, supply disruptions also can increase prices, as the Midwest discovered painfully in August 2001, when regional gasoline prices skyrocketed following a refinery fire at the height of summer demand.[9]

Companies can counter disruptions in material flow by building inventory, or by having redundant suppliers (since it is unlikely that *all* suppliers would be disrupted simultaneously). However, holding inventory in this situation can get very costly. The reason is simple: While holding costs are incurred continually, the inventory would be used only in the rare event of a disruption. In essence, the company pays (and continues to pay) for reserves that may never be tapped. Still, building inventory

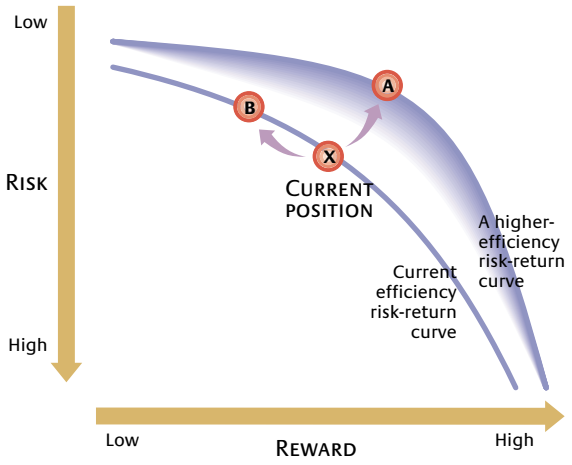
Assessing the Impact of Various Mitigation Strategies

Unfortunately, there is no silver-bullet strategy for protecting organizational supply chains. Instead, managers need to know which mitigation strategy works best against a given risk. (Systems risk and intellectual property risks are not included here.)



Choosing Supply-Chain Risk/Reward Trade-Offs

Perhaps the biggest challenge companies face is mitigating supply-chain risks without eroding profits. The manager's role here is similar to that of a stock portfolio manager: Achieve the highest possible profits for varying levels of risk and do so efficiently. In practice, this entails either (A) moving to a higher level of efficiency by reducing risk while increasing rewards, or (B) remaining at the current level of efficiency by accepting reduced risk and reduced rewards.



does make sense if the disruption can be predicted with reasonable confidence. In 2002, for example, many retailers selectively built up inventories after learning of the impending California dockworker's strike. As a result, when supply was disrupted, as predicted, damage was minimal. Stockpiling inventory as a hedge against disruption also makes sense for commodity products with low holding costs and no danger of obsolescence. The large petroleum reserve kept by the United States is a perfect example of this strategy.

For products with *high* holding costs and/or a *high rate of obsolescence,* using redundant suppliers is a better strategy. Motorola Inc., for example, buys many of its handset components from multiple vendors. Doing so prepares the company for disruptions without building up fast-depreciating inventory. Motorola lowers the cost of redundancy by using multiple suppliers for high-volume products and single sourcing for low-volume products. This approach helps the company lower the risk of disruption while preserving economies of scale at its suppliers.

Systems Risk The more a company networks its information systems, the greater the threat that a failure *anywhere* can cause failure *everywhere.* Although rare, a breakdown of information infrastructure can devastate today's highly networked environments. Case in point: the "Love Bug" computer virus. In 2002, the fast-spreading infection shut down e-mail at the Pentagon, NASA and Ford, among others, causing billions of dollars in estimated damages.[10]

The banking industry has long recognized systems risk as a major threat. In 1988, the Basel Committee on Banking Supervision warned about the growing reliance on globally integrated systems. "The greater use of more highly automated technology has the potential to transform risks from manual processing errors to system failure risks," the committee wrote.[11]

The best defense against systems failure? Robust backup systems and well-designed, well-communicated recovery processes that duplicate all data and transactions. Such approaches helped securities firms recover quickly and convincingly following the World Trade Center attacks in 2001.[12]

Forecast Risk Forecast risk results from a mismatch between a company's projections and actual demand. If forecasts are too low, products might not be available to sell. Forecasts that are too high result in excess inventories and, inevitably, price markdowns. Long lead times, seasonal demand, high product variety and smaller product life cycles all increase forecast error. Errors tend to be greater when a few customers make larger purchases (as opposed to many customers making smaller purchases).

Forecast inaccuracies can also result from *information distortion* within the supply chain. In late 2003, for example, product shortages in Western Europe led Nokia customers to order more than they needed so they would be able to meet demand if Nokia began rationing or allocations. Unfortunately, the exaggerated figures distorted Nokia's reading of the market, causing the company to inaccurately forecast sales.[13]

Other causes of information distortion include promotions and incentives that lead to forward buying; batching of purchases, which leads to higher volatility in orders; and lack of knowledge of end-customer demand at upstream locations. Distortion increases in the supply chain as you get farther away from the end consumer, a phenomenon known as the *bullwhip effect.*[14]

Companies can reduce the sting of the bullwhip effect, though, by adjusting pricing and incentives to decrease variation in orders. Increasing the visibility of demand information across the supply chain also helps. Continuous replenishment programs (CRP), and collaborative planning, forecasting and replenishment (CPFR), and other supply-chain initiatives also can soften the bullwhip effect.

Here again, forecast risk can be lessened by selectively holding inventory and/or building responsive production and delivery capacity. Holding inventory is appropriate for commodity products with relatively low holding costs; responsive delivery is better for expensive products with short life cycles (and corresponding large forecast errors). Motorola practices responsive delivery each day when it flies in phones from China in response to demand by customer Nextel Communications Inc. Instead of stocking parts for uncertain demand, Dell also flies in high-value items from Asian suppliers on an as-needed basis.

Intellectual Property Risk Intellectual property risk has grown rapidly as supply chains become less vertically integrated and more global, and as companies outsource to the same manufacturers used by competitors. Because profitability — and often business models as well — depend on keeping a competitive edge, intellectual property risk has dramatic, long-term implications.

Companies can mitigate intellectual property risk by bringing, or keeping, some production in-house, or at least under direct company control. That is a major reason why Motorola owns some of the testing equipment at supplier locations. Managers also can decrease risk by limiting the flow of new intellectual property into countries with weak legal protections. Companies like Cisco, which outsources all manufacturing, also lower risk by creating business processes that cannot be easily replicated by a single manufacturer. Electronics manufacturer Sharp Corp. even repairs equipment itself, thus preventing any possibility, accidental or otherwise, that its vendors will share proprietary information with Sharp's competitors. The company goes so far as to reprogram various computer-aided machines used by its vendors without sharing the information.

Procurement Risk Procurement risk refers to unanticipated increases in acquisition costs resulting from fluctuating exchange rates or supplier price hikes. For example, the recent weakening

Stress Testing Your Supply Chain

Exploring "what if" scenarios like those below can help groups identify, understand and prioritize risks, a key prerequisite to tailoring effective risk-mitigation strategies.

	Supplier-Related	Internal	Customer-Related
Disruptions	■ Supplier of a key part shuts down plant for a month or at a key part of the production cycle ■ Supplier capacity drops by 20% overnight	■ Key plant shuts down unexpectedly for one month ■ Capacity at a key plant drops by 20% overnight	■ Demand goes up by 20% ... for all products ... for a key product ... across the board ■ Demand goes *down* by 20% under conditions above
Delays	■ Purchase orders of key parts or raw materials delayed by month	■ Distribution or production orders delayed by a month	■ Customer orders delayed by a month
Systems	■ Supplier's order-entry system goes down for a week	■ Key customer's procurement system inside your company goes down for a week ■ Company's inventory/accounts system goes down for a week	■ Order entry system not working for a week ■ Key customer's procurement system inside your company goes down for a week ■ Credit card information stolen from hacked e-commerce system
Information Processing	■ Supplier rations supplies by 20% ■ Supplier increases minimum order size by 20% then 100%	■ To take advantage of volume discounts, company begins to order in quantities twice as large as usual, but half as frequently, which impacts supplier's ability to forecast	■ Key customer begins to order in batches that are twice as large as usual but less frequent (the impact of forecasting)
Intellectual Property	■ Key supplier redesigns parts and creates own product		
Procurement	■ Supplier delays in processing returns by twice as long ■ Supplier forced to increase price of key components by 20% ■ Transportation costs go up 20% overnight	■ Unforeseen cash squeeze requires month-long delays in paying key suppliers	
Receivables			■ Key customer withholds payments one month longer than usual ■ 20% of receivable payments delayed by one month

of the U.S. dollar drove up costs for U.S. companies sourcing in Europe. The devaluation also created the risk of a dollar collapse, the result of Asian economies propping up the currency to maintain exports to the United States. Interestingly, hedging against the dollar's fall also has led to higher oil prices, creating problems for petrochemical and energy-intensive industries. Needless to say, price increases are more likely when a company uses only one supply source. Fortunately, managers have several sharp tools at their disposal for minimizing price increases.

Exchange-rate risk can be countered by creating financial hedges, balancing cost and revenue flows by region and building flexible global capacity. Toyota's manufacturing strategy, to cite one example, allows each plant to serve the local market and at least one other market across the world. This lets Toyota shift production if exchange rates change appreciably.

Price increases by suppliers can be blunted in several ways: by signing long-term contracts, having redundant suppliers or, in rare instances, holding inventory. But be warned that long-term purchasing can badly damage profits if prices for the contracted goods fall. For example, obligations signed by California during the peak of its electricity crisis in 2001 forced the state to pay 800% more than the 2002 market price.[15]

Contracting with redundant suppliers can work, but only if companies can maintain economies of scale. Global giants like Toyota seek out local economies of scale by single-sourcing at the plant level, but enlisting redundant suppliers globally. So even though a company might be the sole supplier to a Toyota plant, it must keep prices down to compete for business across the entire Toyota network. Alternatively, some firms use multiple, redundant suppliers, even if it means sacrificing some economies of scale. Cisco, for one, claims to have four or five more suppliers than it needs. The company keeps the resulting higher costs in check by monitoring and benchmarking suppliers against each other.[16] A good example of using inventory to counter the threat of price increases is the U.S. strategic oil reserve policy. Meant primarily to prevent oil supply disruption, the reserve also has been used on occasion to keep prices down. In another instance, the International Paper Co. keeps prices of raw materials down by sourcing them from independent forest owners, as well as from its own forests.

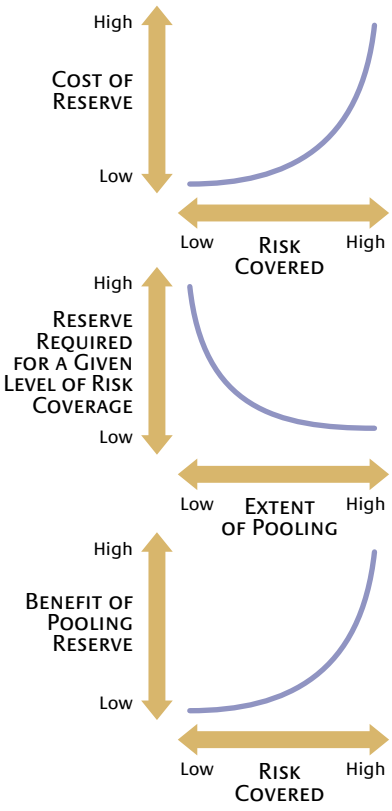
Receivables Risk Receivables risk, the possibility of being unable to collect on receivables, can torpedo the performance of any company. In 2002, Sears Roebuck's credit division reported unexpected losses caused by delinquent cardholders.[17] As a result, Sears stock plummeted more than 30% in one day. The company learned the hard way that filtering customers for creditworthiness is a very prudent and powerful way to reduce receivables risk.

Another approach is to spread the risk across more customers. Elmhurst, Illinois-based McMaster-Carr Supply Co., a maintenance-materials supplier with hundreds of thousands of customers, enjoys a much lower receivables risk than a competitor selling to a single, large customer. The Achilles heel here is a widespread economic shock that harms the creditworthiness of all customers, a fate that befell Cisco during the dot-com bust.

Inventory Risk Excess inventory hurts financial performance. That was the case in late 2000, when the personal computer industry carried roughly 12 weeks of inventory. The killer combination of excess inventory and falling prices hurt many companies, notably Compaq Computer Corp. Inventory risk hinges on three factors: the value of the product, its rate of obsolescence and uncertainty of demand and supply. As we have seen, holding excess inventory for products with high value or short life cycles can get expensive. The strategy can work quite well, however, for low-value commodity products that have low obsolescence rates. To complicate matters even

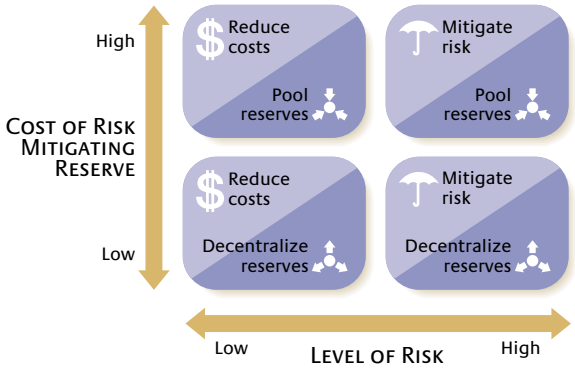
Balancing Supply-Chain Risk/Reward Relationships

Managers working to optimize the cost of building a supply-chain reserve against the level of risk protection must skillfully balance three key relationships. The first relationship shows the increasing cost of risk reduction, which means that using inventory to cover a *high* level of demand risk proportionately costs far more than doing so with a *low* level of demand risk. The second relationship shows that pooling forecast risk, receivables risk or other risk reduces the amount of reserve required for a given level of risk coverage. Thus, the required level of inventory needed to mitigate forecast risk *decreases* as it is pooled. The third relationship illustrates how the benefit of pooling grows with the level of risk covered. This means pooling inventory produces significant benefits only for products with high forecast or inventory risks.



Rules of Thumb for Tailored Risk Management

The application of three key risk/reward relationships in the supply chain (see "Balancing Supply-Chain Risk/Reward Relationships") suggests four general strategic approaches, depending upon the relative level of risk and the cost of mitigating it.



further, inventory risk also increases as product variety grows.

Three time-tested approaches can help managers mitigate inventory risk: (1) pooling inventory, (2) creating common components across products and (3) postponing or delaying the last stage of production until all orders are in hand. Online bookseller Amazon.com serves all its customers in the United States with inventory housed in a handful of warehouses. Book retailer Borders Books & Music supplies its customers with inventory in several hundred stores. Each Amazon warehouse pools demand over a large geographical area, leading to more stable forecasts and lower total inventory. The strategy helps Amazon achieve 14 inventory turns per year, compared with two for Borders.

The paint industry illustrates well how to leverage component commonality and "postponement" of variety. Traditionally, manufacturers held paint inventory in a rainbow of different colors. Today, paint inventory is held as a common base, which is then mixed to exact color specifications after the customer orders. This simple but powerful change has significantly lowered paint inventory at retail stores. Apparel maker Benetton Group SpA also practices pooling and postponement. An inventory of undyed sweaters gets stockpiled in one location; coloring takes place only after specific orders have been received. This pooling of demand across geographical areas, and across colors, helps Benetton greatly reduce inventory risk while more effectively meeting customer demand.[18]

Companies can also minimize inventory risk by working with a highly responsive supplier, especially for high-value, short life-cycle products. Excess capacity can also lower the amount of inventory required. For example, by running plants at 80% utilization, Toyota can handle demand variation without having to hold inventory.

Capacity Risk Unlike inventory, capacity can only be increased or decreased over a period of time. Thus, building excess capacity usually becomes a strategic choice. Excess (and thus, underutilized) capacity hurts financial performance. That was the case in 2002–2003, when many semiconductor firms had to operate at about 50% capacity because of soft demand.

Managers can lower excess capacity risks by making existing capacity more *flexible.* Flexibility is a form of pooling that allows use of the same capacity for a variety of products. For example, plants owned by Japanese truck manufacturer Hino Motors Ltd. employ multiple assembly lines on which the number of workers determines line speed. This flexibility lets Hino change production on any line by moving workers (capacity) to meet fluctuating demand. It also greatly reduces the excess capacity of workers Hino would have to carry if each worked only on a specific line.

Toyota decreases risks from idle capacity by ensuring that each plant is flexible enough to supply more than one market. Demand fluctuations can be satisfied from a variety of plants, which decreases the total capacity required. As noted, Toyota carries the idea of flexibility down to the shop floor, where team leaders can work on any station in the assembly line, reducing the need for spare station-specific workers to cover absences.[19]

Lastly, a company can minimize excess capacity by serving geographically scattered customers from the same location. Italian automaker Ferrari SpA, for example, minimizes total production capacity by centralizing all car production in a single plant. The arrangement also gives Ferrari economies of scale, even though the company procures and produces much less than the big auto companies.

What Managers Should Do

With so many related risks and risk-mitigation approaches to consider, managers must do two things when they begin to construct a supply-chain risk management strategy. First, they must create a shared, organizationwide understanding of supply-chain risk. Then they must determine how to adapt general risk-mitigation approaches to the circumstances of their particular company. Managers can achieve the former through *stress testing* and the latter through *tailoring.*

Stress Testing Stress testing is a group exercise that helps managers and their companies understand and prioritize supply-chain risks. "What if" scenarios help key players focus on the supply chain one link at a time. This strategy offers an especially effective way to gain buy-in and shared ownership in project teams tackling supply-chain risk.

The first step in stress testing is to identify key suppliers, customers, plant capacity, distribution centers and shipping lanes. Next, the team surveys locations and amounts of inventory represented by components, work-in-process and finished goods. Man-

agers then probe each potential source of risk, which helps assess possible supply-chain impacts as well as the company's level of preparedness. Facilitators ask questions such as, "What might happen if a particular supplier could not deliver for a month?" or "What if a supplier raised prices by 20% at the termination of a contract?" Questions pertaining to key customers might include: "What if demand went up or down by 20%?" or "What if a customer delayed cash payment by a month?" (See "Stress Testing Your Supply Chain," p. 57.) When considering questions during stress testing, managers should realize that figures such as "20%"or "one month" are not sacred, but simply represent numbers large enough to be significant and small enough to be realistic.

It is wise to position stress testing as a "thought experiment" to help the company prepare for unforeseen events, rather than focusing on the debatable likelihood of such events. Similarly, it is useful to frequently remind people of the goal: preparing the supply chain for unforeseen events and greatly lowering risk, both at the lowest possible cost.

Through stress testing, managers should be able to identify risk-mitigation priorities for the near, medium and long term. They will have identified product families at risk, as well as individual plants, shipping lanes, suppliers or customers that could pose risks. Managers will also have a clear idea of what risks might have an impact on sales, procurement costs, revenues, prices or even reputation.

Tailoring Risk Management Approaches Leading companies mitigate risk by building various forms of reserves, including inventory, capacity, redundant suppliers and responsiveness. Managers must keep a vigilant eye on the trade-off between the risk and the cost of building a reserve to mitigate it.[20] Three key relationships influence this optimal balance. (See "Balancing Supply-Chain Risk/Reward Relationships," p. 58.)

The *first* relationship is the increasing cost of risk reduction. This simply means that using inventory to cover a high level of demand risk costs much more than covering a low level of risk. The *second* relationship shows that pooling forecast risk, receivables risk or some other risk reduces the amount of reserve required for a given level of risk coverage. Thus, the required level of inventory needed to mitigate forecast risk decreases as it is pooled. The *third* relationship shows how the benefit of pooling grows with the level of risk covered: The benefit of pooling inventory is great only if the product has high forecast or inventory risk.

Managers can balance these relationships to tailor their response to risk with a surer grasp of extent and cost of reserve. The following rules of thumb can be applied to tailor risk-mitigation strategies: When the cost of building a reserve is low, reserves should be decentralized. When the cost is high, reserves should be pooled. If the level of risk is low, focus on reducing costs. If the risk is high, focus on risk mitigation. (See "Rules of Thumb for Tailored Risk Management," p. 59.) By tailoring reserves for all risk-mitigation strategies, companies can maximize rewards for the same level of risk, or lower risks for the same reward. (See "Tailoring Reserves for Risk Mitigation.")

Tailoring Reserves for Risk Mitigation

Once a company clearly understands its supply-chain risk, it can select the appropriate general mitigation approach and specific tailored strategy.

Mitigation Approach	Tailored Strategies
Increase Capacity	■ Focus on low-cost, decentralized capacity for predictable demand. ■ Build centralized capacity for unpredictable demand. Increase decentralization as cost of capacity drops.
Acquire Redundant Suppliers	■ Favor more redundant supply for high-volume products, less redundancy for low-volume products. ■ Centralize redundancy for low-volume products in a few flexible suppliers.
Increase Responsiveness	■ Favor cost over responsiveness for commodity products. ■ Favor responsiveness over cost for short life-cycle products.
Increase Inventory	■ Decentralize inventory of predictable, lower-value products. ■ Centralize inventory of less predictable, higher-value products.
Increase Flexibility	■ Favor cost over flexibility for predictable, high-volume products. ■ Favor flexibility for low-volume unpredictable products. ■ Centralize flexibility in a few locations if it is expensive.
Pool or Aggregate Demand	■ Increase aggregation as unpredictability grows.
Increase Capability	■ Prefer capability over cost for high-value, high-risk products. ■ Favor cost over capability for low-value commodity products. ■ Centralize high capability in flexible source if possible.

Beyond reserve costs, companies must also consider product volumes. Fast-moving standard items, with low margins and low forecast risk, call for different reserves than slow-moving special products with high margins and greater forecast risk. When planning capacity, managers should select an efficient, low-cost supplier for fast-moving (low-risk) items. In contrast, a more responsive supplier better suits slow-moving (high-risk and high-value) items. For example, Cisco tailors its response by manufacturing fast-moving products in specialized, inexpensive but not-so-responsive Chinese plants. High-value, slow-moving items are assembled in responsive, flexible (and more expensive) U.S. plants. Sony Corp. also exploits this strategy, utilizing flexible but high-cost plants in Japan and low-cost but specialized plants in Malaysia and China.

As much as possible, a specialized, decentralized approach offers the best way to keep capacity for *fast-moving,* commodity items with *low forecast risk.* Doing so should produce greater responsiveness and lower transportation costs — but only if doing so maintains adequate economies of scale. In contrast, capacity for *slow-moving, short life-cycle products* with *high* forecast risk should be made more flexible and centralized to pool demand. This helps explain why automakers, for example, often build specialized plants for fast-moving products in each major market, but centralize the flexible production of high-end, slower-selling models.

When capacity is expensive, managers can reduce supply-chain costs by centralizing capacity to pool risk. As costs decline, capacity must be decentralized further. Consider the personal computer industry. PCs can be assembled to order in two different ways. In one, the Dell model, capacity is centralized. In the other model, widely used in India, several companies sell component kits to local assemblers for assembly on demand. Given the low cost of assembly capacity in India, it is economical to decentralize capacity, even though this action reduces pooling and increases the overall size of assembly capacity across the supply chain. In contrast, given the higher cost of capacity in the United States, centralizing buffer capacity is more effective.

In addition to separating products with different risk characteristics, managers must also consider separating *capacity* for the low-risk and high-risk aspects of each product. Utility companies use this strategy by employing low-cost, coal-fired power plants to handle predictable *base* demand, and utilizing responsive but high-cost gas- and oil-fired power plants to handle uncertain *peak* demand. Similarly, Benetton produces the predictable base load of its knit garments using a cheaper process that starts with dyed thread and only produces the uncertain portion using the more expensive process of dyeing knit garments.[21]

By continually stress testing their supply chains and tailoring reserves, managers can protect and improve the bottom line in the face of many types of supply-chain risks. Like Ericsson, smart companies do not wait for lightning to strike twice before taking action.

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