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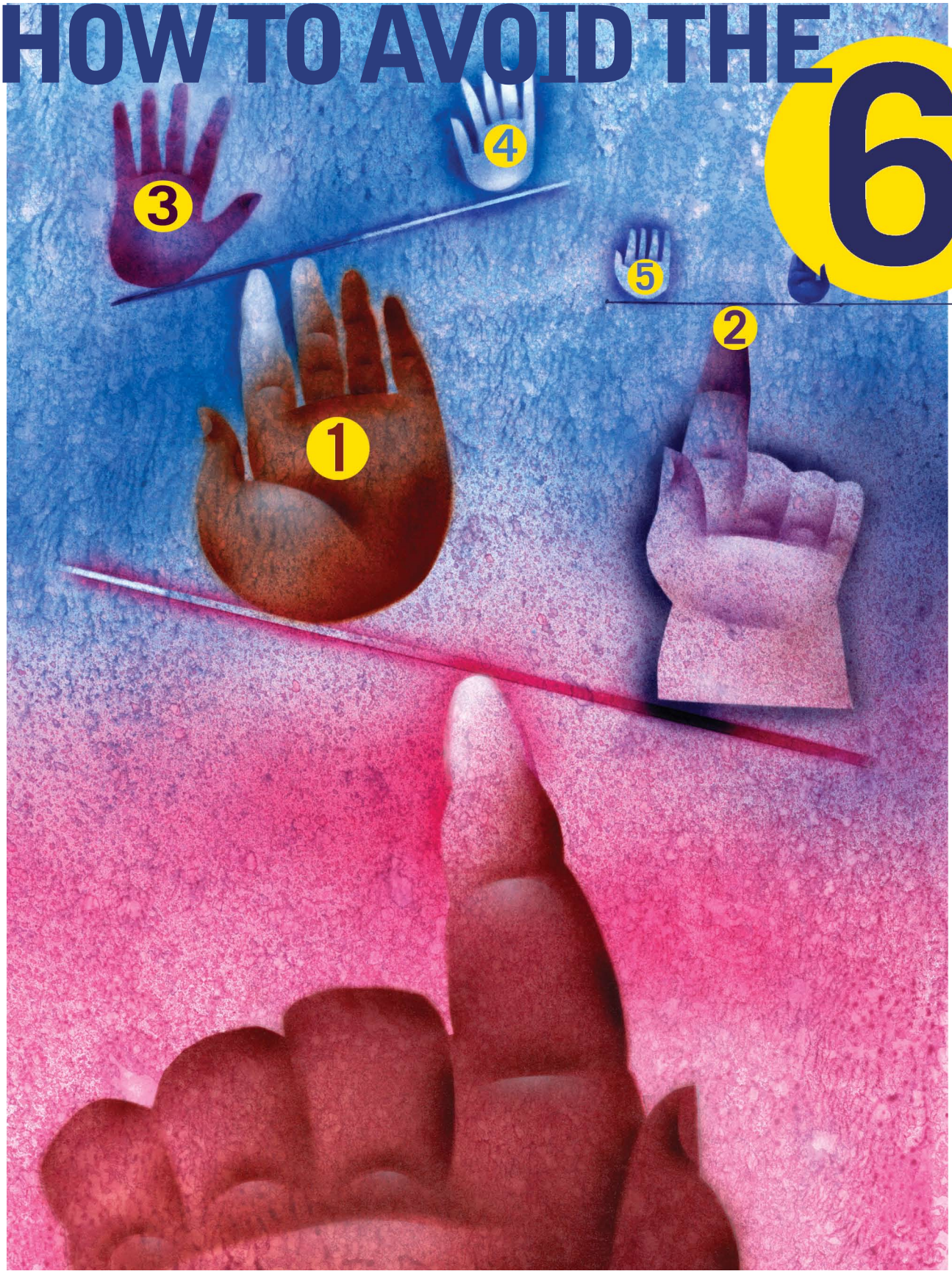

Todd Davidson

RISK MANAGEMENT PITFALLS

By Jayashankar M. Swaminathan and Brian Tomlin

As a result of a three-week strike at its largest manufacturing plant in February 2007, Harley-Davidson announced that its first quarter shipments of motorcycles would be 20 percent lower than planned and that its 2007 earnings-per-share growth would be in the 4-6 percent range rather than in the projected 11-17 percent range. Harley-Davidson was not the only company hit by an operations crisis that month. A combination of icy weather and poor planning crippled JetBlue's operations for nearly a week, leading to the cancellation of hundreds of flights. In addition to the negative publicity and damage to its customer-service reputation, JetBlue estimated that the February crisis could cost the airline more than $30 million. Toward the end of February, Navistar cut off supply of diesel engines to Ford because of a contract dispute. This interruption compelled the automaker to stop production at its Louisville, Ky., truck plant. Despite the fact that the courts ordered Navistar to resume supply in early March (and for both parties to negotiate further), Ford acknowledged that March sales of its highly profitable F-Series Super Duty pickup truck would be hurt by the supply stoppage.

Examples such as these highlight the continuing need for both manufacturing and service companies to develop robust and resilient operations. While the lessons learned from past disruptive events, such as the 2002 West Coast port stoppage, have led to upgraded risk management practices, there is still much room for improvement. In this article, we identify and discuss six oft-overlooked pitfalls of effective risk management in the supply chain. These pitfalls fall under three categories: assessing supply chain risks, managing supply chain risks, and developing a supply chain risk strategy. We offer advice on how to navigate these pitfalls and conclude with a set of recommendations for improving supply chain risk management.

Companies are increasingly recognizing the importance of supply chain risk management. While some have made impressive strides in improving their risk evaluation practices in recent years, much work remains to be done. In this article, we discuss risk assessment, risk mitigation, and the importance of a consistent and coherent supply chain risk strategy. We identify six specific pitfalls that managers should be aware of and discuss how they can be avoided, and conclude with some strategic recommendations for moving forward.

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Assessing the Supply Chain Risks

In the aftermath of the breakdown in JetBlue's operations, CEO David G. Neeleman said, "I wish we could have simulated this on a computer program instead of living it real time. We learned some huge lessons. They will be ingrained in us for a long, long time."[1] In fact, one of the lessons other companies have learned in recent years is to do scenario planning and simulate possible disruptive events.[2] This enables the organizations to gauge

their ability to respond and make improvements as necessary. Such exercises, sometimes referred to as stress testing, are a vital element of effective supply chain risk assessment. In stress-testing you create "what-if" scenarios (such as "what if my key supplier shuts down for a month?") and then develop mitigation and/or contingency plans to reduce the probability and/or the impact of the scenario.[3] A business unit of the research and engineering firm SAIC Inc. recently tested whether all of its employees could effectively work outside the office in the event of a flu outbreak.[4] This test identified a number of software problems that needed to be resolved. The idea of stress testing supply chains is becoming increasingly popular and is recommended by many large insurance companies as part of their business-interruption insurance services. However, there are two important pitfalls to avoid when stress-testing your operations.

1 Pitfall 1: Assuming disruptions can only occur when operating at normal strength

Madagascar is the largest producer of vanilla, accounting for over half of the world's supply. In 2000, Cyclone Hudah ruined 30 percent of Madagascar's vanilla vines and 100 tons of inventory. In reaction to the shortage-induced price increase, countries such as Uganda, India, and New Guinea increased their planting of vanilla. Vines, however, take four years to mature and so recovering to pre-cyclone supply levels took years. A second supply disruption, in the form of political upheaval, hit Madagascar in 2002. The flow of goods into Toamasina, the country's primary port, was blocked for many weeks. The price of vanilla surged from an already-high price of $60 per gallon to over $200 per gallon over the course of the following months. Although this second disruption happened two years after Hudah struck, it still had such an extreme effect because the industry had not yet recovered from the storm's impact.

Typically, the "what-if" scenarios used in stress-testing exercises assume that a disruption occurs under normal operating circumstances. That is, the operational buffers — such as excess inventory or capacity the firm uses to protect itself against disruptions — are at full strength prior to the event. Unfortunately, operational buffers are not elastic; they do not snap back to pre-disruption levels once the disruption ends. It takes time to restore buffers, and any disruption during the restoration phase has a much larger impact than under normal circumstances. Exhibit 1 shows the near-term impacts of the buffer-restoration process. This is particularly true for companies, or industries, in which capacity is tight. The less capacity, the longer it takes to clear backlogged customer demands and to restore operating buffers.

After a fire devastated the Philips Semiconductor plant in Albuquerque, N.M. in 2000, knocking out the company's production of computer chips for about six weeks, Ericsson instituted a rigorous supply-risk management program. Managers use the so-called Ericsson Risk Management Evaluation Tool to help stress test their supply chains.[5] By identifying possible disruption sources and evaluating their impact as measured by the subsequent business recovery time, Ericsson's supply-continuity teams developed plans to manage potential disruptions. When stress-testing your supply chain, you need to consider the possibility of a disruption hitting your company when you are not at full strength. You need to assess how long it takes to fully recover from a disruption — that is, how long it takes not just to clear backlogged demand but how long it takes to get back to normal protection levels. You need to ask questions such as "what if a second unrelated disruption occurs while we are recovering from the original disruption?" By appropriately factoring in recovery time and the possibility of follow-on disruptions, stress testing can more effectively identify and mitigate vulnerabilities in the supply chain.

EXHIBIT 1

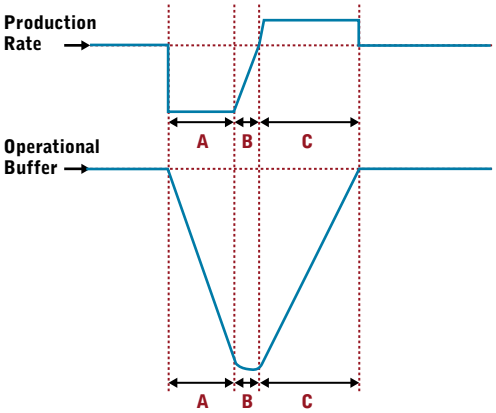
Buffer-Restoration Temporarily Reduces Resiliency

Your operational buffer (inventory in this example) offers protection against demand and supply uncertainties. A disruption depletes the buffer and it can take time to completely restore it to the pre-disruption level even after production resumes. During this restoration phase, you are less resilient than under normal circumstances and so the impact of any new disruption is much higher than would normally be the case.

A. Disruption: Production is halted during the disruption. The operating buffer diminishes as sales cannot be replenished by production. The buffer might be completely used up, at which point it will go into negative territory if customers are willing to backlog their orders or it will remain at zero if customer sales are lost.

B. Resumption: After the disruption ends, it typically takes some time to ramp production up to the pre-disruption rate so that it can keep up with demand. During the resumption phase, the buffer continues to deplete but at a slower pace.

C. Restoration: Now that production has been ramped to a rate sufficient to keep up with the demand, you can clear any customer backlogs and start to rebuild your operating buffer by running production at a higher-than-normal rate. Once your operating buffer has been restored, the production rate can return to its normal level.



2 Pitfall 2: Assuming yours is the only company affected by a disruption

During the 2002 West Coast port disruption, many companies that routinely shipped goods by sea decided to temporarily airfreight their goods as an emergency solution. These companies were in for a rude awakening. The price of charter flights from Asia jumped 30 percent in a week, from $300,000-350,000 to $400,000-450,000 per flight.[6] This was not due to price gouging; rather demand for airfreight increased dramatically as companies scrambled to move their goods from Asia to North America. Companies that under normal circumstances might not even be competitors found themselves suddenly battling for a scarce resource. Because of this, even those companies who were willing to pay a higher airfreight price were often unable to get their goods on a flight. At the very least, they experienced significant delays in getting their emergency transportation option up and running. A similar issue hit Ericsson during the Phillips Semiconductor disruption in 2000; Nokia acted faster in securing emergency capacity and Ericsson found itself unable to obtain adequate emergency supply in a timely fashion.

The attractiveness of emergency sourcing as a supply-continuity tactic depends not only on the cost but also on the speed at which the emergency supplier can be activated as well as the level of additional throughput the supplier can sustain. Because resource competition makes the cost, activation speed, and available capacity of emergency suppliers uncertain, you need to ask questions like "What if our emergency supply costs 25 percent more than we expect?", "What if it takes us twice as long to activate the supply?", or "What if we only get 50 percent of the capacity we expect?" By asking these questions, you might find that relying on an emergency supplier is a less enticing continuity-sustaining tactic than you thought.

Alternatively, you might be tempted to enter into contracts with emergency suppliers to guarantee availability when needed. This can be a good idea but bear in mind that suppliers can't guarantee capacity they don't have. To illustrate, nursing homes in the U.S. are required to sign contracts with transportation companies to provide evacuation services in the event of an emergency. During Hurricane Katrina, however, some nursing homes found out they had contracted with the same provider and this provider had insufficient capacity to fulfill its contractual obligations when multiple facilities required their service at the same time.

Contracts are helpful but strong relationships can sometimes do even more in a crisis. During the scramble for airfreight during the 2002 West Coast port disruption, Solectron's relationships with key freight providers enabled the company to get the courier capacity it needed.[7] According to Solectron's Jim Molzon, "We think it is important to establish longstanding relationships with key providers of air freight services to ensure that we get lift out of a region when we need it." Building lasting relationships to ensure priority allocation is particularly important in countries such as China where personal connections and relationships (or "guanxi") can trump contracts.

Managing Supply Chain Risks

In an effort to improve resiliency, some companies have launched supply-continuity initiatives. The focus on managing supply-continuity risk has helped companies enhance their supply resiliency. However, it is rare for such initiatives to factor in demand risk when evaluating supply-continuity plans. Likewise, initiatives focused on managing demand risk often ignore supply risk because that is the domain of the supply-continuity program. This separation would be acceptable if supply and demand risks were in fact independent. The problem is that supply and demand risks can interact in subtle but critical ways. In their ongoing risk-management activities, managers must carefully consider the interaction—and in particular avoid the following pitfalls.

Typically, the "what-if" scenarios used in stress-testing exercises assume that a disruption occurs under normal operating circumstances.

3 Pitfall 3: Ignoring the supply risk associated with demand-pooling tactics

A popular tactic for managing demand uncertainty is to invest in operational buffers (inventory or capacity) to ensure that demand can be met with a high probability. Yet operational buffers can be expensive. Furthermore, a higher service level is accompanied by a higher risk of unused buffer. That is, protecting against high demand scenarios results in a large amount of excess inventory or capacity if a low-demand scenario materializes. In sizing operational buffers, companies must trade off the risk of not meeting demand with the risk of excess inventory or capacity. The higher the desired service level, the higher the required buffer investment.

Companies that produce multiple products can use demand pooling to reduce the relative uncertainty that their operational buffers are protecting against. In a postponement strategy, for example, demand across multiple products or regions is pooled and buffer inventory in the form of a semi-finished product is stored.[8] Other important demand-pooling strategies include the development of flexible plants and standardized (common) components to serve demand for multiple products. Demand pooling enables companies to

provide the same service level for a lower buffer investment (or provide a higher service level for the same buffer investment.) In effect, demand pooling allows you to operate on a new—and more favorable—service-buffer tradeoff curve.[9] By shifting your trade-off curve, you can release money that was tied up in the buffer and put it to more profitable uses. This can provide immense value. In fact, leading companies in recent years have expended great effort in redesigning supply chains to take advantage of demand pooling.

Unfortunately, pooling initiatives often overlook a hidden risk: demand-pooling tactics may concentrate your supply and, therefore, increase your supply risk. We illustrate this hidden risk for the case of flexible plants, but the same logic applies to component commonality. Imagine you are deciding how best to configure your manufacturing plant network. You could choose a dedicated configuration in which each product is produced in a separate dedicated plant or a pooled configuration in which all products are produced in a single flexible plant. The pooled configuration minimizes your demand risk and lets you operate on a better service-buffer tradeoff curve. However, the pooled configuration maximizes your supply risk because a failure at the flexible plant shuts off supply of all your products. An interruption to one product is serious, but possibly manageable. An interruption to all products can be catastrophic. See Exhibit 2 for an illustration of the supply and demand risks associated with both configurations.

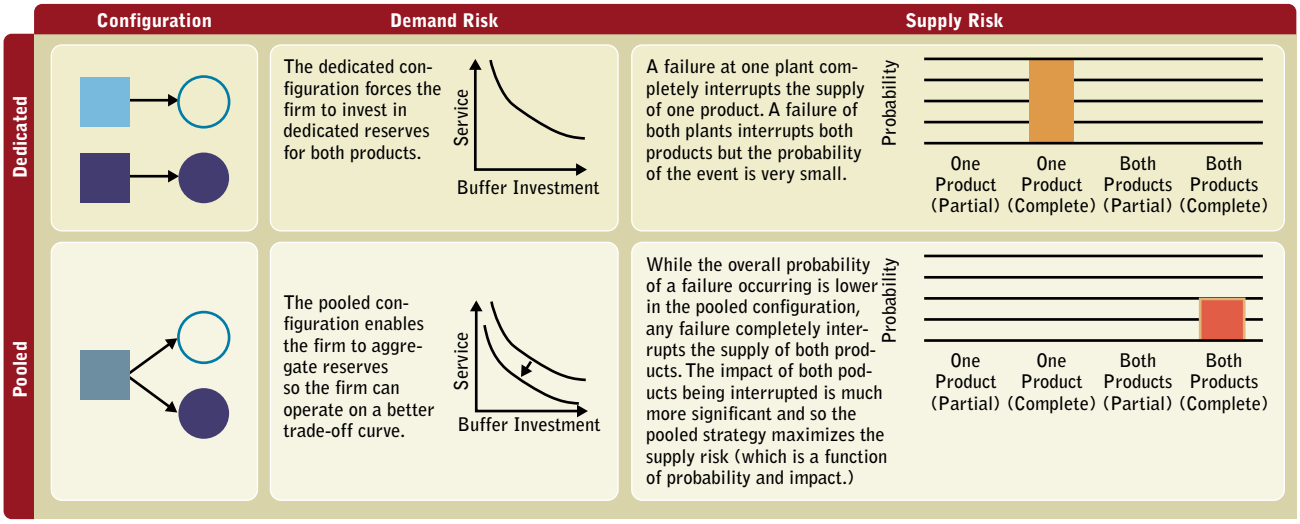
Must you choose between minimizing demand risk through a pooling strategy and minimizing supply risk through a dedicated strategy? Fortunately, the answer is no. There is a third way that offers almost all the demand-risk benefit of a pure pooling strategy and a lower supply risk than either strategy. By intelligently combining pooled and dedicated resources, you can simultaneously protect against demand and supply risks. This hybrid strategy is shown in Exhibit 2. Other hybrid strategies such as the chaining configuration used for assembly-plant networks in the automobile industry also offer supply-risk benefits in addition to their primary demand-risk benefit.[10]

Commonality and flexibility programs are driven by a desire to manage demand risk. Their success in reducing demand risk often comes at the hidden expense of increased

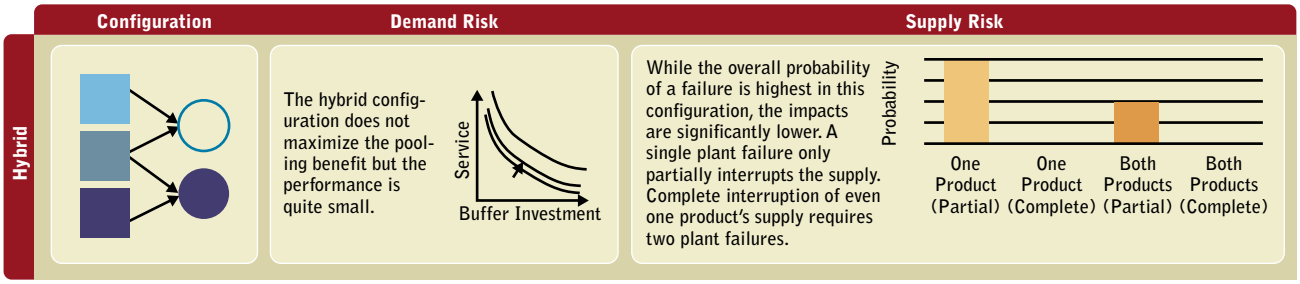
EXHIBIT 2

Demand Pooling Can Increase Supply Risk

(a) The pooled configuration has a lower demand risk but a higher supply risk as compared to the dedicated configuration



(b) A hybrid strategy can be very effective at managing demand risk and also gives the lowest supply risk



supply risk. As a result, pure demand pooling strategies that are considered so effective under normal operating conditions tend to be less effective when one takes supply risk into account. Therefore, you should include supply risk as a factor when evaluating possible demand-pooling strategies.

4 Pitfall 4: Ignoring demand risk when choosing a supply-continuity tactic

Because pooling increases your supply risk, you should factor in supply risk when evaluating demand pooling tactics. Likewise, you should factor in demand risk when evaluating supply-continuity tactics—not because supply-continuity tactics increase your demand risk but because your demand risk can significantly alter the desirability of a continuity tactic. As such, the choice of supply continuity tactic should not be made without understanding your demand risk.

In the fashion, toy and certain technology industries, product lifecycles are short and supply leadtimes are long. Companies have to source most, if not all, of their product in advance of their selling season. Buffer inventory is not a very effective supply-continuity tactic in such environments for two reasons. First, the buffer inventory can be stocked only if the original supply is not interrupted, and this defeats the purpose of the buffer. Second, obsolescence costs are especially high in short lifecycle industries, making inventory expensive. Firms must therefore rely on dual-sourcing, backup sourcing, and demand management to manage their supply risk.

Backup (or emergency) sourcing, whereby you source from an alternative supplier in the event of a failure at your primary supplier, can be attractive in a high risk-averse environment. However, it becomes less attractive as demand risk grows. Backup suppliers that can expedite delivery (as is necessary if your primary supplier fails) typically charge a high premium as compared to your primary supplier. This higher cost is especially burdensome if the demand risk is high; you cannot afford to buffer against high demand scenarios, as the cost of leftover product is a prohibitive risk. Increasing demand risk therefore reduces the value of the emergency-supplier tactic. (We note that if your emergency supplier is fast enough to allow you to order again during your selling season, then emergency supply does offer a demand-risk benefit).

Dual sourcing, whereby you simultaneously source from two suppliers, actually becomes more attractive as demand risk grows. When dual-sourcing, you should not simply order the same total quantity of product as you would if you single sourced. Instead, consider ordering a larger total quantity because part of the order from each supplier can be used as a buffer against a failure to the other supplier. Imagine that you lived in a world with no demand uncertainty. In this case, these supply buffers would only help in the event of a supply failure. Because demand is uncertain, however, your supply buffers offer additional protection against high demand scenarios. While this is only a secondary benefit of the buffers, it does mean that dual sourcing is more attractive as demand risk grows.

During the worldwide memory shortage resulting from the 1999 Taiwanese earthquake, Dell was able to induce some customers to purchase lower-memory computers rather than higher-memory versions. Other computer firms that lacked this capability were less able to cope with the supply shortage. Demand management, whereby you shift a portion of demand for one product to another, is helpful only if you have an excess of one product and a shortage of another product. Scenarios in which there is an excess of one product and a shortage of the other are much more likely to occur if demand is uncertain. In the absence of demand uncertainty, an excess/shortage combination is unlikely as you would have to purposefully order an excess of one product in anticipation of a supply failure for another product. As such, the primary benefit of demand management is in managing demand risk while managing supply risk is only a secondary benefit.

Because demand risk influences the merits of supply-risk tactics and supply risk influences the merits of demand-pooling tactics (see Pitfall 3), companies should jointly manage both risks rather than managing each in isolation. Hewlett-Packard (HP), a leader in supply chain risk management, achieves this through its Procurement Risk Management (PRM) Group, which is responsible for demand, supply and cost risks. The PRM Group has developed scenario-based methods to quantify demand, availability, and cost uncertainties, allowing the company to make holistic supply-chain decisions that account for all three sources of uncertainty.[11] Since 2000, the PRM group has rolled out its risk-management approach to about 1,000 people across multiple functions in HP.

Plan of (and for) Attack: Developing the Risk Strategy

In essence, developing a supply chain risk strategy is all about balancing operational risk and reward. But remember, achieving the right balance can be difficult. It is complicated both by attitudes towards risk and differences between managerial and corporate planning horizons. In particular, managers need to be mindful of these two recurring pitfalls.

5 Pitfall 5: Allowing managers' risk attitudes and timelines to determine strategy

Will two managers looking at the exact same supply chain and the exact same risk scenarios choose the same resiliency level and tactics? Not necessarily—it depends on their risk tolerances and their planning horizons.

Managers vary in their tolerance for risk and, absent a company-wide resiliency policy, this will be reflected in their willingness to invest in resiliency. Moreover, even if willing to invest in supply-chain resiliency, a manager's choice of tactics can be influenced by his/her tolerance for risk. Let us

again consider industries with short product lifecycles and long supply leadtimes. How do risk attitudes affect the desirability of the three continuity tactics—backup sourcing, dual sourcing and demand management? Demand management is effective only if you have an excess of one product and a shortage of another. But how can this scenario come about? To have an excess of one product, you must have ordered more than what was eventually demanded. In other words, you were willing to take the risk of having excess product if a high-demand scenario did not materialize. If you have an aversion to risk, then you will be less willing to expose yourself to this excess-inventory risk and so will order less product. In doing so, you reduce the likelihood of excess of one product in the event of a supply failure of the other product, and so you further reduce the usefulness of demand management as a supply-continuity tactic. Assuming you have a guaranteed backup supplier, emergency sourcing becomes increasingly preferred over dual-sourcing as you become more risk averse. The best supply-continuity tactic, therefore, depends not only on the supply and demand risks, but on the decision maker's tolerance for risk.

In essence, developing a supply chain risk strategy is all about balancing operational risk and reward.

How much should you invest in supply-chain resiliency? That depends on how vulnerable you think you are to a disruption. How vulnerable are you to a disruption? Well, that depends on your timeframe. The likelihood of a disruption in the next quarter might be tiny. The likelihood of a disruption over the next five years might be somewhat greater, but still small. However, it's not so small as to be ignored. This highlights the fact that the appropriate level of resiliency depends heavily on the time horizon being considered. This is especially true in the case of rare-but-severe disruptions. Managers may draw down the level of resiliency dramatically as the end of their planning horizon approaches because the trade-off between current operating costs and future supply risk shifts to the cost side because the likelihood of a disruption in the remaining horizon decreases. A failure to align managers' resiliency-planning horizons with longer-term corporate-planning horizons can, therefore, result in companies taking on a higher level of operational risk than is appropriate.

If you allow the risk attitudes and planning horizons of individual managers to determine resiliency, you cannot expect to have a consistent and coherent policy across your organization. Some managers may under-invest in resiliency while others over-invest. To guard against this, you should develop and roll out standardized risk-assessment and risk-management procedures across your organization.

6 Pitfall 6: Building short-term resiliency at the cost of long-term vulnerability

Even when your managers incorporate supply chain resiliency as a goal in their near-term planning, you need to ensure that their near-term continuity plans don't plant the seeds of long-term supply risk.

As companies outsource an ever-larger portion of their operations to Chinese suppliers in an effort to reduce costs, they expose themselves to an increased supply risk. While the Chinese government is emphasizing energy, logistics, and transportation infrastructure investments, goods sourced from China still run a higher risk of production and transportation delays than do goods sourced from more established economies. A tactic to hedge your risk exposure without sacrificing the cost benefit is to source from multiple Chinese suppliers. Multiple-sourcing will certainly increase your short term resiliency. However, it also might expose you to significant long-term risks. Intellectual property rights are still fluid in China. If in the act of outsourcing, you share proprietary technology or product design information, you run the risk of unwittingly creating a long-term competitor, as the athletic footwear company New Balance has experienced. You also potentially run the risk of lower-quality, counterfeit product being sold in your packaging. This can expose your company to significant warranty and customer-attrition risks. Multiple-sourcing increases the risk of IP leakage and counterfeit competition.

The idea that suppliers will not act in your best interests, often referred to as "supplier gaming," is by no means limited to China. Some companies value the strong relationship that can be built by single-sourcing from a supplier. This close relationship can pay off in terms of priority allocation in the event of a disruption. It can also make a supplier more willing to engage in ongoing process-improvements to reduce the likelihood of disruption. Unfortunately, single sourcing can also expose your company to hold-up situations. It is not unheard of for U.S.-based suppliers to use the implicit (or sometimes explicit) threat of order delays to extract monetary concessions from their key customers.

Managing supply risk cannot be viewed as an intermittent activity to be carried out every few years. Decisions about resiliency that you make today can play out in unexpected ways. You need to be continually vigilant in scanning for changes in your operating environment that may necessitate adjustments to your resiliency strategy.

Moving Forward

The companies that successfully navigate these six pitfalls will be the same ones that excel at supply chain risk management. To ensure sustainability of this key competency, companies should take the following actions.

Make supply chain risk management an executive-level priority. Too often operational risks only get the attention

of senior executives after a disruptive event causes a crisis. Rather than reacting to events, senior executives should be proactive about supply chain risk management. A resilient operation does not evolve naturally from the ground up. It requires appropriate managerial incentives, a process for prioritizing risks and allocating resources across products and departments, the implementation of cross-functional practices, and possibly the creation of new organizational structures. Incentives, budget allocation, cross-departmental practices and new organizational structures are the purview of senior executives. Therefore, supply-chain risk management cannot be effective without executive-level support.

Create a full-time supply chain risk champion. Disruptive events help raise awareness of operational risks and there is a heightened focus on assessing and managing future risks in the immediate aftermath of a disruption. Unfortunately, this attention to risk can wane over time as the repercussions of the past crisis fade from the organizational memory. To prevent backsliding, executives should create the position of a supply-chain risk champion who not only oversees and coordinates all supply chain risk activities, but also develops tools and best practices. Supply chain risk management is an emerging discipline and in many ways companies are inventing processes and procedures as they go. A full-time risk champion is better positioned than are managers with part-time risk responsibilities to identify, create, and roll out standardized best practices across the company. In larger companies, there may be a need for the risk champion to have a support team.

Engage the whole organization in supply chain risk management. The creation of supply chain risk champion does not remove the line managers' responsibility for managing operational risk. While the risk champion provides critical guidance and infrastructural/process support to line managers, he or she will not have a rich enough understanding of all the product lines, processes and systems to adequately identify, prioritize and plan for risks, nor will that individual have sufficient bandwidth to monitor all supply chain activities for early warning signs of elevated risks. Line managers must be responsible for owning and managing the risks in their area. All employees should be encouraged to identify possible risks, suggest ways to reduce risks, and to keep their eyes and ears open for early warning signs of impending disruptive events.

Collaborate on risk management with suppliers and customers. Building resilient internal operations and robust sourcing strategies reduces, but does not eliminate supply chain risk. Your company might source from two suppliers. But what if these suppliers both single source a key component from the same upstream supplier? If your key customer shuts down due to a disruption to their operations, how long will it be before this demand interruption forces a temporary stoppage to your operation? While improving internal resiliency may provide the best return initially, working with supply chain partners to enhance their resiliency may provide a better return as your internal risks reduce. Moreover, collaboration will allow for the sharing of best practices and tools. Given the evolving nature of supply chain risk management, casting a wide net can keep your company on top of industry standards and best practices.

Supply chain risk management is an emerging discipline. Companies that procrastinate and wait for the discipline to mature will find themselves at a competitive disadvantage. Customers will increasingly view effective operational risk management as a qualifier for doing business. Also, supply chain crises provide well-prepared companies with a great opportunity to poach customers from poorly prepared ones. By acting now—and keeping an eye out for these six pesky pitfalls—your company can put itself at the forefront of this important discipline.

REFERENCES

1 C.A. Miranda, "Can JetBlue Weather the Storm?," *Time Magazine*, February 21, 2007. http://www.time.com/time/business/article/0,8599,1592096,00.html

2 Y. Sheffi, "The Resilient Enterprise," (Cambridge: The MIT Press, 2005).

3 S. Chopra and M.S. Sodhi, "Managing Risk to Avoid Supply-Chain Breakdown," *MIT Sloan Management Review* 46 (Fall 2004): 53-61.

4 D. Brown, "Business Plan for a Pandemic?," *Washington Post*, May 2, 2006.

5 A. Norrman and U. Jansson, "Ericsson's proactive supply chain risk management approach after a serious sub supplier accident," *International Journal of Physical Distribution and Logistics Management* 34 (No. 5 2004): 434-456

6 J. W. Schoen, "Port Closures Will Hurt Holiday Sales," MSNBC. October 7, 2002, msnbc.msn.com/id/3073054/

7 D. Bartholomew, "Cargo Crunch," *Industry Week* 254 (March 2005): 42-48.

8 S. Venkatesh and J.M. Swaminathan, "Managing Product Variety through Postponement: Concept and Applications", *The Practice of Supply Chain Management: Where Theory and Application Converge*, edited by Corey Billington, Terry Harrison, Hau Lee and John Neale, 139-156, Kluwer Publishing, 2003.

9 J. Neale, B. Tomlin and S. Willems, "The Role of Inventory in Superior Supply Chain Performance", *The Practice of Supply Chain Management: Where Theory and Application Converge*, edited by Corey Billington, Terry Harrison, Hau Lee and John Neale, 31-59, Kluwer Publishing, 2003.

10 W.C. Jordan and S.C. Graves, "Principles on the Benefits of Manufacturing Process Flexibility," *Management Science* 41 (April 1995): 577–594.

11 V. Nagali, "Procurement Risk Management at Hewlett-Packard Company," (presentation at the workshop on Integrated Risk Management in Operations and Global Supply Chain Management, Ann Arbor, MI, June 1–4, 2006).