

APICS INSIGHTS AND INNOVATIONS

SUPPLY CHAIN RISK AND REWARD

MEASURING RISK IN YOUR SUPPLY CHAIN



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COUNCIL

ABOUT THIS REPORT

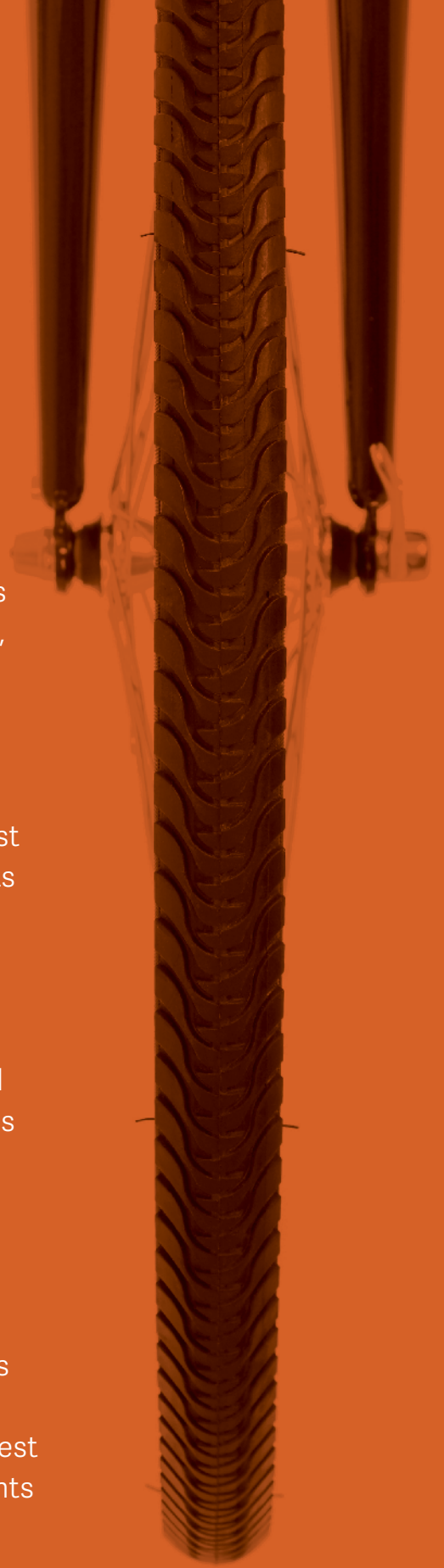
APICS conducted a survey to examine practices, procedures and plans in risk management across the supply chain. The survey was designed to provide a closer look at real-world risk management practices.

This report looks beyond the survey results and provide guidelines designed to help advance your organization's risk measurement, management and risk reward analysis.

APICS Research Reports are based on practitioner surveys that explore trending topics in supply chain and operations management. They include survey results, analysis, tips and best practices to keep you and your organization informed of insights and innovations in supply chain and operations management.

This report was developed by APICS Supply Chain Council, an organization that advances supply chain and operations management and innovation through research, education, and publications. APICS SCC maintains the Supply Chain Operations Reference (SCOR) model, the supply chain management community's most widely accepted framework for evaluating and comparing supply chain activities and performance. For more information, visit apicsscc.org.

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These programs and publications provide resources and detailed information about the topic.

**APICS Risk Management
Certificate Program**
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Risk:

The *APICS Dictionary, 14th Edition*, defines Supply Chain Risk as "The variety of possible events and their outcomes that could have a negative effect on the flow of goods, services, funds or information resulting in some level of quantitative or qualitative loss for the supply chain."

EXECUTIVE SUMMARY

Risk is a cost. Reward is the actual or anticipated benefit. And not every reward is worth the risk. This is true everywhere, including supply chains. The goal is to reduce or eliminate the risks that fail to offer adequate rewards through risk-reward analysis.

Think of risk-reward analysis as similar to cost-benefit analysis. While risk itself may be unavoidable, there may be choices on the specific risks you have to face based on the design and operation of the supply chain.

When analyzing a supply chain risk, ask the following questions: What is the reward for enduring the risk? Is the risk worth the reward?

This APICS report provides insights, select articles from APICS Magazine, and four tools that will help you determine supply chain risk and reward at your organization:

1. Risk and Reward Probability and Impact Decision Chart
2. Monte Carlo Simulations
3. Value at Risk
4. Time-to-Recovery: Establishing Recovery Time Objectives and Roadmaps

Consider the Related Terms from the APICS Dictionary

Risk acceptance: A decision to take no action to deal with a risk or an inability to format a plan to deal with the risk.

Risk avoidance: Changing a plan to eliminate a risk or to protect plan objectives from its impact.

Risk register: A report that has summary information on qualitative risk analysis, quantitative risk analysis and risk response planning. This register contains all identified risks and associated details.

Risk response plan: A document defining known risks including description, cause, likelihood, costs and proposed responses. It also identifies current status on each risk.

Measuring Risk in Your Supply Chain

In cause and effect terms, enduring a risk creates the opportunity for a reward, but it must be a reward worth having. In terms of risk and reward balance, ask yourself which side has the greatest weight and consequence? When it comes to financial investment, greater risk has the potential to deliver greater reward. A risky supply chain should deliver greater reward over a less risky one. The “market” for determining the worth of the reward and the cost of the risk comes from business unit strategy, competitors and customer demands.

A company whose strategy is built on speed and flexibility and that operates a supply chain to match would appear to have a riskier supply chain compared to an organization whose strategy is based on operating with the lowest cost as a priority. Both supply chains value the balance of risk and reward differently. A careful study of business unit strategy or supply chain strategy may reveal a supply chain that endures risks but delivers no worthwhile reward or benefit. This is similar to a product that doesn't deliver a value equivalent to its price. Avoid these risks when possible. Where this is impossible,

- Reduce the risk
- Share or transfer the risk until it presents a better risk-reward balance
- Increase the reward for enduring the risk

Analyzing risk and reward balance, and translating the cost and the benefit of each risk is not often straightforward because the cost of risk and the benefit of reward often move along different timelines.

Balancing Risk and Reward Over Time

Assets, tasks, processes or activities that repeat or continue over time tend to operate according to predictable balances of risk and reward. However, they may present the occasional or rare catastrophic risk, a risk that offsets even long periods of reward. Even rare or improbable risks become probable with enough time or repetition.

Consider the example of a distribution fire center and fire insurance.

Operating a distribution center presents a mix of risks and rewards. The distribution center offers extensive logistic rewards, but requires enduring a number of unavoidable risks, including fire. Paying fire insurance premiums prevents a fire from destroying years of reward. Nevertheless, the rewards of the distribution center must be sufficiently high to offset the cost of the insurance premiums. If the distribution center reward achieves this, then the risk-reward balance of distribution center fire remains weighted on the side of reward. This is a risk worth enduring. Without transferring this risk to an insurance company, even the rare risk of a distribution center fire may not be worth years of reward.

There is not yet insurance for every supply chain risk. Or available insurance costs offset expected reward. This means sharing risk, mitigating risk or self-insuring against risk across the supply chain. Supply chain strategy helps clarify risk and reward worth facing. This means that supply chain risk management must continually investigate and evaluate appropriate risk and reward balances. Because supply chain managers can't address all risks, they should focus on specific risks, particularly those that have an undesirable risk and reward balance.

The *APICS Operations Management Body of Knowledge (OMBOK) Framework* best practices for risk management entails a three-step process:

1. Identify the sources of potential disruptions.

The first step is to assess the types of vulnerability in a supply chain. The focus should be on highly unlikely events that would cause a significant disruption to normal operations, including natural disasters, capacity failures, infrastructure failures, terrorist attacks, supplier failures, labor actions, equipment failures, price volatility, and military and civil conflicts.

2. Assess the potential impact of the risk.

Next, quantify the probability and the potential impact of the risk. The assessment depends on the specific incident, but it can be based on factors such as finance, environment, business viability, brand image and reputation, and human lives.

3. Develop plans to mitigate the risk.

Finally, create a detailed strategy for minimizing the impact of the risk. These strategies can take different forms depending on the nature of the problem.

Examples of Risk Mitigation Strategies

Risk	Risk Mitigation Strategy
Transportation failure	Use of redundant vehicles, modes and operators
Supplier failure	Sourcing from multiple suppliers
Climate change, inclement weather	Contingency planning, including alternate sites; insurance
Licensing and regulation issues	Up-front and continuing research; legal advice; compliance
Major quality failure	Careful supplier selection and supplier monitoring
Loss of customers	Innovation of products and services
Theft or vandalism	Insurance; security precautions; knowledge of likely risk; patent protection

Risk and Reward Life Cycle

Risks and rewards may not occur along the same timeline. Risks may be immediate while rewards may take longer to achieve. Many rewards require upfront risk investments. A risk investment is the state of enduring an immediate risk in exchange for a reward. For example, a factory under construction imposes a series of risks such as protecting the building site and equipment already completed during construction, risk of a competitor discovering proprietary production processes by observing the construction before factory walls are built, and completion of necessary supporting infrastructure on time, but does not yet provide a reward for enduring those risks. Over time, the risks will be offset. Rewards created by risk investment often have a life cycle. An aging factory, for example, may begin to present additional new risks but not provide additional new rewards.

To evaluate supply chain in this way, focus on major supply chain assets, as well as the repetition of important tasks and processes. Are the risks “risk-lean” for the reward they provide? In other words, are the risks reduced to the lowest level possible, just as lean calls for reducing waste to the lowest level possible, while still delivering what is required? Do they demand the least risk for the most desirable reward? Are the risks volatile? Do the risks tend to vary often or widely or are they steady? Do they tend to create new risks over time, which are not offset by suitable reward? Where are the risks in terms of life cycle? Technology may suddenly render obsolete existing assets and processes by creating new options with a much improved risk and reward balance. Continuing with outdated assets and processes can impose an unfavorable balance compared to competitors.

If a risk must be endured and cannot be mitigated, transferred or reduced, then develop greater reward for enduring the risk. If the risk outweighs the reward and increasing the reward is not possible, make sure business unit strategy guides planning and decision making. Also, be sure that senior management is aware of the risk and reward balance. This is common when entering a distant new market. An organization or its supply chain may have to endure risks and losses in the short term in order to create a permanent profitable position in the long term. In this case, the organization or its strategy or senior management may be willing to endure more risk than your supply chain risk management would normally tolerate.

When thinking about risk and reward life cycle, consider the following questions:

For each point in the supply chain, is risk-reward a value-add or the best value?

Is the burden of risk and the benefit of reward spread equally across the supply chain?

Risk and Reward Probability and Impact Decision Chart

Evaluate supply chain plans and activities according to their anticipated risks and rewards. Results may suggest altering the plan or activity, or not implementing them. For a given plan or activity add up its expected risk probability and impact over time. Then add its expected probability of reward and impact over time. Subtract the risk total from the reward total.

Risk condition	Risk probability and impact Score 1-10	Reward probability and impact Score 1-10	Net balance
Move to new production processes	Change management process fails = 4 Impact = 10 Score 24	Greater productivity achieved = 7 Impact = 10 Score 17	A difference of +3 indicates that the risk is worth the reward.
Eliminate one distributor partner	Service levels fall unacceptably = 6 Impact = 8 Score 14	Net expenses fall = 5 Impact = 8 Score 13	A difference of -1 indicates you should mitigate or transfer risk where possible.
Add new supplier	Additional supply complexity = 9 Impact = 2 Score 11	More supply diversity = 10 Impact = 1 Score 11	A difference of 0 is neutral
Outsource production of core	Supply disruption = 5 Impact = 9 Score 14	Free up capacity in current facilities = 8 Impact = 3 Score 11	A difference of -3 indicates that you should consider alternatives to avoid this risk. If impossible to mitigate, then transfer, reduce risk or work to increase the expected reward.

Monte Carlo Simulations

Monte Carlo simulation replicates real-life outcomes by accounting for random variables and revealing the most probable outcomes or consequences of specific actions. This information helps with risk evaluation or decision-making processes.

Scenario

Suppose a factory is scheduled to close for 10 days of essential maintenance. However, you learn that all the factory maintenance workers are considering a strike. The number of strike days is unpredictable. This means the factory will be closed anywhere from at least 10 days up to 25 days.

Consider the following conditions:

- Imagine that your organization loses 500 scheduled units of production each day the plant is closed beyond day 10.
- Imagine that your organization loses a customer for every 1,000 units of lost production.
- How many customers might the organization lose due to the maintenance worker strike?

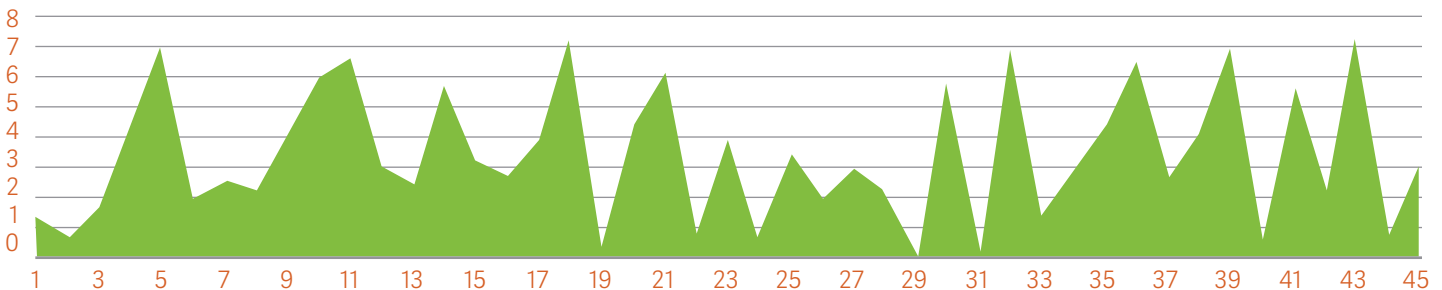
You can use Monte Carlo simulations to explore the ramifications. In a spreadsheet format such as Excel, enter the following information:

Cell A1 = 10 + RAND()*15	The spreadsheet displays a random number of days between 10 and 25.
Cell A2 = (A1-10)*500	The spreadsheet calculates the number of lost units at 500 units each day above 10 days.
Cell A3 = (A2)/1000	The spreadsheet calculates the number of lost customers based on lost production for 1,000 or more units.

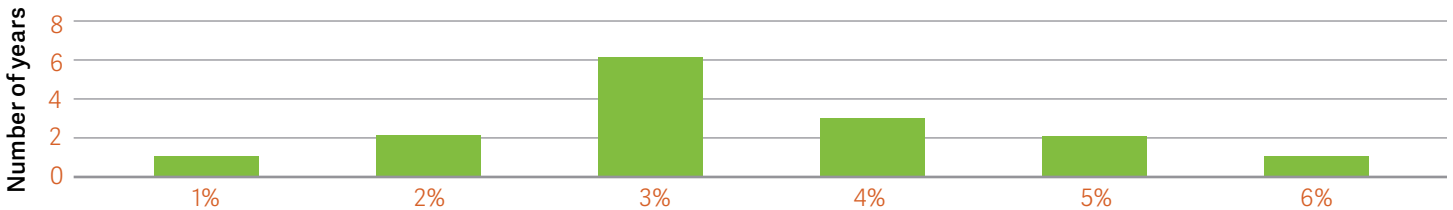
Recalculate the spreadsheet (press F9 in Excel) several times to display a range of possible lost customers. If you recalculate the spreadsheet many times and record each lost customer value, you can determine an average number of lost customers. If you graph the results, you see how common, rare, likely or unlikely specific lost customer results are.

For example, over 45 recalculations you might find an average of three customers lost. If you were to graph the number of lost customers over 45 recalculations, you would see that extremes of either no lost customers or seven lost customers are possible, but are not as likely as other values. It is now easier to anticipate the probable impact of the maintenance worker strike.

Potential customers lost from strike risk



15-year distribution of annual portfolio rates of return



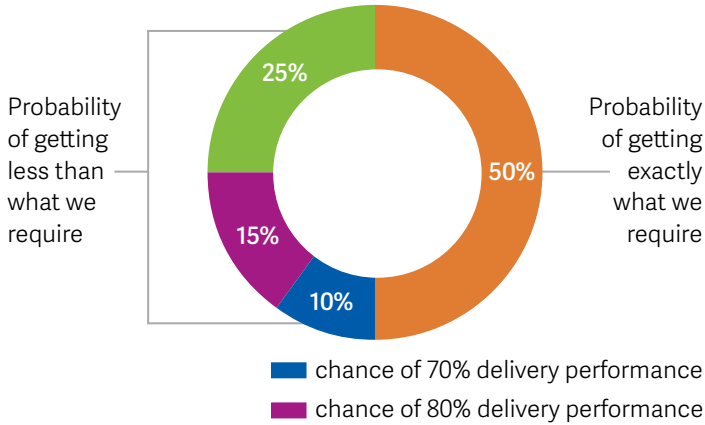
Value at Risk

The concept of Value at Risk (VaR) originated in the financial industry. It seeks to calculate a financial portfolio's range of most and least probable gains or losses overtime. Extremely high or low portfolio gains and losses are rare but still possible. They represent a best-case or worst-case scenario. More probable are an average level of gains or losses over time. Knowing the expected range of gains and losses enables a financial manager to evaluate or forecast the likely value of a portfolio despite random fluctuations of financial markets.

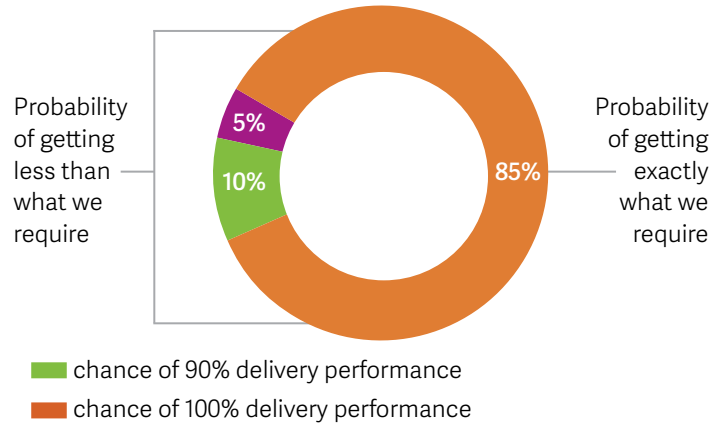
VaR allows one portfolio to be compared to another. Portfolios that are volatile, meaning those that show large swings in value over time, exhibit greater risk than nonvolatile portfolios. If two portfolios provide the same return, but one is more volatile, the more volatile portfolio requires enduring more risk for the same return. Its balance of risk and reward is not as favorable. VaR calculations may use actual historical values, calculation of standard deviation, or Monte Carlo simulation. For example, a portfolio with an average 2.5 percent annual gain over 15 years may show the following "bell shaped" distribution of gains, with the top of the "bell" representing the most common value.

VaR can serve supply chain risk management. Instead of the range of returns of a portfolio, VaR can calculate and compare the relative value of supply chain partners in terms of their performance and reliability. How? Suppose your organization values good supplier delivery performance. Yet with every supply chain partner or supplier there is the risk of delivery underperformance. Suppose your organization also values low cost suppliers. However, low-cost suppliers have worse delivery performance than high-cost suppliers. In terms of delivery performance, VaR enables comparison of the risk of underperformance between suppliers. This helps determine an optimal risk and reward balance among such suppliers.

Supplier 1: history of delivery performance



Supplier 2: history of delivery performance



Is a riskier supplier worth the reward of lower cost? Suppose your organization completed a study of supply chain supplier delivery performance over the last three years. Over many orders, the study showed the probability of varying levels of delivery performance for two suppliers: Supplier 1 and Supplier 2.

What is this supplier worth in terms of VaR? Convert these statements of probability into score values.

- For example, 10 percent chance of 70 percent delivery performance converts to $.1$ multiplied by $(100 - 70)$. Simplified, this is the same as $.1(30)$. The final result equals three. Therefore, the probability expression "10 percent chance of 70 percent delivery performance" is equal to three. Repeat the same process for all the probability expressions where we get less than what we require. For example, $VaR = .1(100 - 70) + .15(100 - 80) + .25(100 - 90) = 3 + 3 + 2.5 = 8.5$. Supplier 1 has a VaR delivery risk score of 8.5. How does Supplier 1 compare to Supplier 2?
- As before, convert the expressions to VaR expressions and calculate the VaR delivery risk value. $VaR = 0(100 - 70) + .05(100 - 80) + .10(100 - 90) = 0 + 1 + 1 = 2$. Supplier 2 has a VaR score of two. The lower value is better. If both Supplier 1 and 2 were equal in every other way (price, quality, services) Supplier 2 presents better delivery performance risk than Supplier 1.

Time-to-Recovery: Establishing Recovery Time Objectives and Roadmaps

The earlier sections of this report address evaluating risk and reward, but these evaluations do not address how to optimize responsiveness when a supply chain risk event or disruption occurs. The business continuity field developed the concept of a recovery time objective (RTO). From a supply chain risk perspective RTOs set the duration of time (and service level) that a disrupted supply chain operation must be restored in to prevent unacceptable consequences in supply chain continuity. Ideally, RTOs are based on current analysis and the practical, real-world capability of the supply chain. RTOs combined with a recovery roadmap of anticipated tasks create an actionable time-to-recovery resource.

Risks that are reasonably probable and require lengthy RTOs, particularly RTOs exceeding the time before unacceptable supply chain consequences develop, demand careful attention of the supply chain risk manager by developing supply chain RTOs and related recovery roadmaps. RTOs call for a rapid and efficient use of time once a risk condition or disruption develops. Given the urgency, complexity and variability of supply chain risks, RTOs and roadmaps may vary greatly.

The Four Ds of Duration

An RTO and recovery roadmap should account for the following four phases:

- 1. Detect** the actual risk condition - the first symptom may not reveal the actual risk condition.
- 2. Develop** a response—tailor and prioritize responses to the risk and its causes and disruptions.
- 3. Deploy** the response—execute the response in the challenging conditions the risk.
- 4. Determine** the effectiveness—measure actual reduction of the risk condition and its disruptions, not merely reduction of immediate symptoms.

Detect

Early detection of risk requires making risk indicators visible through regularly observed metrics, alarms, triggers, and constant comparison of optimal non-risk states to present supply chains. Hard risk is a risk that is measurable or quantifiable. Hard risk often includes risks such as damage or destruction to physical assets and can be measured or calculated. Soft risk is a risk that is difficult to measure or quantify. Soft risks occupy the intangible domain of the supply chain, such as

leadership strength, quality of relationships, trust or information sharing. An example of soft risk is a supplier that has taken on greater debt levels. This may be for good or bad reasons (good might be borrowing to fund a new factory, and bad might be to finance poor management) but increasing debt does make claims on the future earnings of the supplier. The repayment of debt may one day begin to claim capital needed to provide good service. It is not easy to measure this risk as new debt may enable capacity and technology to grow revenue well beyond the costs of repayment and provide increasingly good service.

A key practice of early risk detection is continuous analysis of supply chain soft risks, such as declining communication, weak relationships, and incomplete or late information flow. Many supply chain disruption risks become worse, require more effort to recover from, or are more probable when soft risks increase. If soft risks continually increase, address soft risk directly while increasing risk detection of the hard risk conditions they may bring. For example, a supplier that has become less responsive to your communication and relationship efforts may be starting to face financial pressures that impact hard risks related to quality or delivery.

Develop

Developing a response requires first an accurate determination of the cause of the risk condition, as well as prioritization of the effort needed to swiftly address the risk condition and return to the pre-risk state. Across a supply chain, complex risks may present a variety of symptoms that may not obviously suggest the cause of the risk. Build a reliable base of information, confirm with stakeholders the conditions they seek, and ask 'the five whys' to confirm causes. According to the *APICS Dictionary*, 14th Edition, "the common practice in total quality management is to ask 'why' five times when confronted with a problem. By the time the answer to the fifth 'why' is found, the ultimate cause of the problem is identified." Developing a response tailored to the risk rather than reacting to it can be critical to containing the risk condition.

Deploy

Successful rapid deployment of a risk response condition requires high levels of communication, coordination, information sharing and flexibility. Yet people tend to respond to risk conditions with slow, confused or unproductive action even in the face of obvious problems and solutions. The reason is that risk conditions create unfamiliar circumstances and in turn, call for unfamiliar actions. Staff and partners across a supply chain wonder: Do I have the authority? Am I making matters worse? What if I am blamed for something that goes wrong?

Deployment should account for human nature with clear direction, authority and leadership across the supply chain. Don't count on these attributes developing by themselves during the risk condition. Define, document and secure agreement in advance by working out optimal deployment agreement for categories of probable risk conditions and disruptions that would have significant impact to your supply chain. Examples of categories might include natural disasters, financial crisis, significant loss of information or information technology capability, product or service liability crisis, significant asset theft and more.

Determine

Determining the effectiveness of the response is a discovery process that operates first as parallel with the deployment of the risk response, and later during post-mortem, lessons-learned phase once the risk condition has passed. This phase requires communication, coordination and information sharing. As deployment proceeds, ask immediate questions of team members: is the wrong RTO and recovery roadmap in use? Is the recovery roadmap impeded by any unexpected challenges? Are we still discovering new risk conditions that complicate an effective recovery? Is recovery taking more time than the RTOs permit?

During the later post risk condition phase, ask questions:

- What were our strengths?
- What weaknesses should be strengths?
- Where did we make the risk worse?
- How could we have shortened the duration of the four phases as the risk condition occurred?

To minimize the duration of each of these phases begin by sharing supply chain risk plans across the supply chain. Ask for your partners for supply chain risk plans and share your own. Determine RTOs for common risks jointly. Are there ways to develop faster detection of risk conditions or to develop and deploy solutions? Follow up these questions with joint determination of effectiveness during the risk and after the risk condition. Work out RTOs and recovery roadmaps in advance by anticipating the time required to detect, develop, deploy and determine. Practices mock drills or scenarios. Evaluate and update as risk conditions and risk management capabilities change across the supply chain.

Risk and Reward Best Practices

Take the following steps to implement risk management at your organization:

Know your business unit and supply chain strategy. Stay knowledgeable about how much risk is manageable in your physical, operational and information technology domains. Know what risks would have the most damage. Another source of risk is a supply chain suffering from poor strategic alignment. Supply chain strategy helps determine risk levels by defining the best alignment of supply chain partners, practices, assets and performance for the current and future needs of an organization.

Maintain and build relationships to facilitate easy networking across the supply chain. Share your supply chain risk and reward evaluations. Are they shared across the supply chain? Where are perspectives different?

Account for hard and soft risk as well as hard and soft reward. Soft risk is risk that is difficult to measure or quantify. Examples of soft risk might include losing top management leadership, failing relationships or unfavorable market trends. It may be difficult to quantify what losses or disruptions might occur. In contrast, a hard risk could be a fire at a warehouse. It is possible to delineate fire-related losses or disruptions in terms of lost inventory, expenses or recovery costs. Reward also comes in hard and soft formats. Hard rewards, such as greater production, lower costs or managing the smallest inventory that still gets the job done are measurable. Soft rewards are harder to measure. For example, an improving reputation or level of trust among supply chain partners may be difficult to quantify, but it is a desirable reward nonetheless.

Keep the balance of risk and reward current over time. Trends, technologies, competitor actions and newly discovered risks and rewards may change the balance over time. Gather perspectives from a variety of sources, including buyers/planners, schedulers, material managers and supply chain managers. Where do they see the most risk? Where do they see the most reward? Of the risks facing the supply chain, what do they see as probable or improbable from their perspective? Knowing why they answer the way they do will help capture insight and lead to innovation.



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