Achieving Supply Chain Resilience

How to Reduce Vulnerabilities Through Quantitative Risk Sensing

White Paper

Preamble

The COVID-19 pandemic has transformed the way we perceive the importance of risk management and resilient management in a myriad of ways. The first phase of the pandemic led to a supply shock in China that was followed by a demand shock due to the shutdown of global economies. The combined demand and supply disruption revealed vulnerabilities of today's highly dispersed and interlinked supply chains, their strategies and related corporate objectives of almost all globally acting companies.

The Path to a Resilient Supply Chain

In this new environment, building resilient supply chains is more important than ever. The conceptual challenges for building resilience are numerous: uncover hidden risks, identify supply chain vulnerabilities, build or improve supply chain resilience, diversify the supply base and many more. Building resilient supply chains enables companies to respond **in a quick and agile way** to changing market demands. Therefore, a resilient supply chain not only helps companies gain key competitive advantages in a dynamic environment. It is also best equipped to withstand unforeseen and disruptive events.

But how to evaluate which resilience strategy is best for the specific situation your supply chain is facing? How to define concrete measures and how to implement them into the supply chain process landscape? In this white paper, we present answers to these questions. Follow us right into the machine room of real supply chain risk management and learn about the main steps of a framework for Quantitative Risk Sensing.

We wish you beneficial and informative reading!

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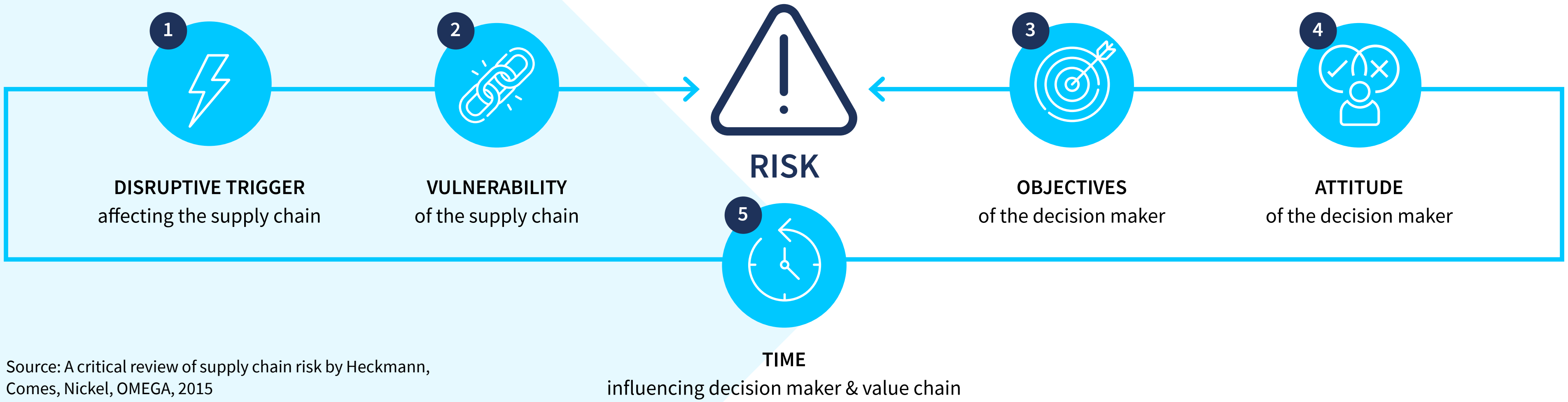
Initial Analysis: Core Characteristics of Supply Chain Risks

The COVID-19 pandemic shows that we need to change our risk management processes and think in terms of “what can we do now, to prepare for the next unknown, whenever it will occur.” But even if risk management is very common, we can still see some degree of confusion and lack of precision of terms related to the topic. However, it is important to get the concepts and terms right, as this is the key to correctly setting up supply chain risk management. When it comes to risk in general and supply chain risk in particular, it is important to be aware of the various characteristics that define the extent of supply chain risk.

FROM OUR PROJECT EXPERIENCE, WE CAN IDENTIFY FIVE CORE CHARACTERISTICS OF SUPPLY CHAIN RISKS



Source: A critical review of supply chain risk by Heckmann, Comes, Nickel, OMEGA, 2015

1 Disruptive Trigger

The most obvious characteristic of supply chain risk is a trigger. Most triggers refer to a certain event. However, it does not necessarily have to be an event, but could also be any shift that develops over time, e.g. a price increase or shift in demand between regions. Without a trigger that affects the supply chain, supply chain risk would not manifest, and we would really live in a deterministic world. The nature of risk propagation, the impact on supply chain processes, and the impact on supply chain parameters such as lead times, capacity, and cost must be assessed. The takeaway message here is that predicting potential trigger events and their impact on supply chains is not efficient, because we will keep on chasing events. We therefore emphasize the importance to assess how a potential trigger can most presumably and directly affect relevant supply chain processes when they occur. The “how” can then be represented by an uncertainty value, like a probability distribution.

2 Vulnerability

In order to understand which processes are sensitive to changes of their nominal supply chain parameters, the level of vulnerability has to be assessed – more detail is given on the next pages. While the majority of existing solutions and services focus on the identification of disruptive events like earthquakes or labor strikes and their related impacts on the supply chain environment like border crossing or transportation delays, we emphasize the importance of first identifying and quantifying supply chain vulnerabilities, e.g. with the metric time-to-sustain.

3 Supply Chain Objectives

Besides the increased prioritization of vulnerability quantification, we stress the importance of how to evaluate the extent of vulnerability, i.e., its unit. It is of utmost importance to evaluate supply chain risk in terms of business relevant KPI. There is no need for an additional risk index, mainly because it does not help in decision making for further supply chain stabilization measures. Instead, in order to decide how much risk to reduce, it needs to be defined in terms of what is tracked on a daily, weekly or quarterly basis, such as customer service levels, profit margin, costs or production utilization.

4 Decision Makers‘ Attitude

Normally, decision makers know what they do not want to become "real". They know what is good, still good, bad, or very bad in terms of their business relevant KPI, and where the tipping points between these levels lie. For example, a decision maker would not rate a service level decrease by 1% as a risk, but he would do so in the case of a 5% decrease. Different decision makers might formulate different thresholds they are willing to accept. Risk analysis, vulnerability assessment, and resilient decision support need to reflect this by identifying various scenarios.

5 Time

It is time that makes evaluating supply chain risk so difficult. Business, supply chain environment and the afore described risk characteristics are dynamic and interdependent, so they very often change over time: delays of three days for raw material supply might not be a problem for production, but four days are. The eruption of the Icelandic volcano in March 2010 imposed a huge threat to the automotive industry – a disruption during Christmas time several weeks earlier would have not been that relevant, as production was closed anyway.
A risk analysis at a specific point in time might be invalid a couple of weeks later.

Perfect Timing: The Best Resilient Response Depends on Time

Resilience response measures intend to increase the resistance towards disruptions, the **recovery capabilities** after disruptions, or both. Resistance capabilities aim to absorb the impact of a critical change and include building capacity, inventory or time buffers into sourcing, manufacturing, or distributing supply chain processes. **Recovery capabilities** intend to quickly rebound to normal operations after processes have been disrupted. This makes it easier to increase or decrease production volume.

RISK MEASURES RELATED TO RESISTANCE, RECOVERY OR BOTH

		RESISTANCE	BOTH	RECOVERY
DIRECT RISK MITIGATION	SC design		Network design, Multiple sourcing, Modular design, Flexible lines, Cross-training, Long-term contracts	
	Planning & configuration	Risk stock, Postponement, Stock buffer mgmt.	Generic inventory, Capacity reserves, Alternative routes	
	Security	Firewalls, Quarantine, Physical systems		
INDIRECT BUSINESS INSURANCE	Financial protection			Cash reserves, Liquidity, Credit lines, Long-term refinancing, Risk insurance
	Goodwill & influence		Brand equity, Customer relationship, Supplier relationship, Innovation capital, Partnerships	
PREPAREDNESS	Monitoring	Supplier monitoring, SC visibility, Risk screening, Demand sensing	External collaboration, Supplier risk plans	
	Contingency		Risk assessment	Contingency plans, Crisis taskforce, Training & rehearsing, Backup infrastructure

When it comes to considering time before and during a disruption, there are four points in time which drive different mitigation approaches: announcement of a disruption, start and end of impact of a disruption and re-start of the normal phase or a "new" normal phase.

1. Any mitigation action **prior to the announcement** of a disruption belongs to the group of pro-active options. Appropriate resilient adjustments to supply chain processes and strategies must be identified, prioritized, and implemented. With respect to the afore mentioned capabilities, pro-active measures can improve resistance, recovery or both and need to be prepared on a mid- to long-term basis. Examples include risk stock, modular design, or supplier contracts.

2. Any mitigation action executed **after the announcement** belongs to the group of re-active options and can be further classified according to the duration and development of a disruption. First, re-active preparation includes short-term preparation actions before the impact of a disruption hits the supply chain such as filling the stocks, shifting to other suppliers, shifting to alternative transportation modes – i.e. adjusting supply chain processes with respect to the present need.

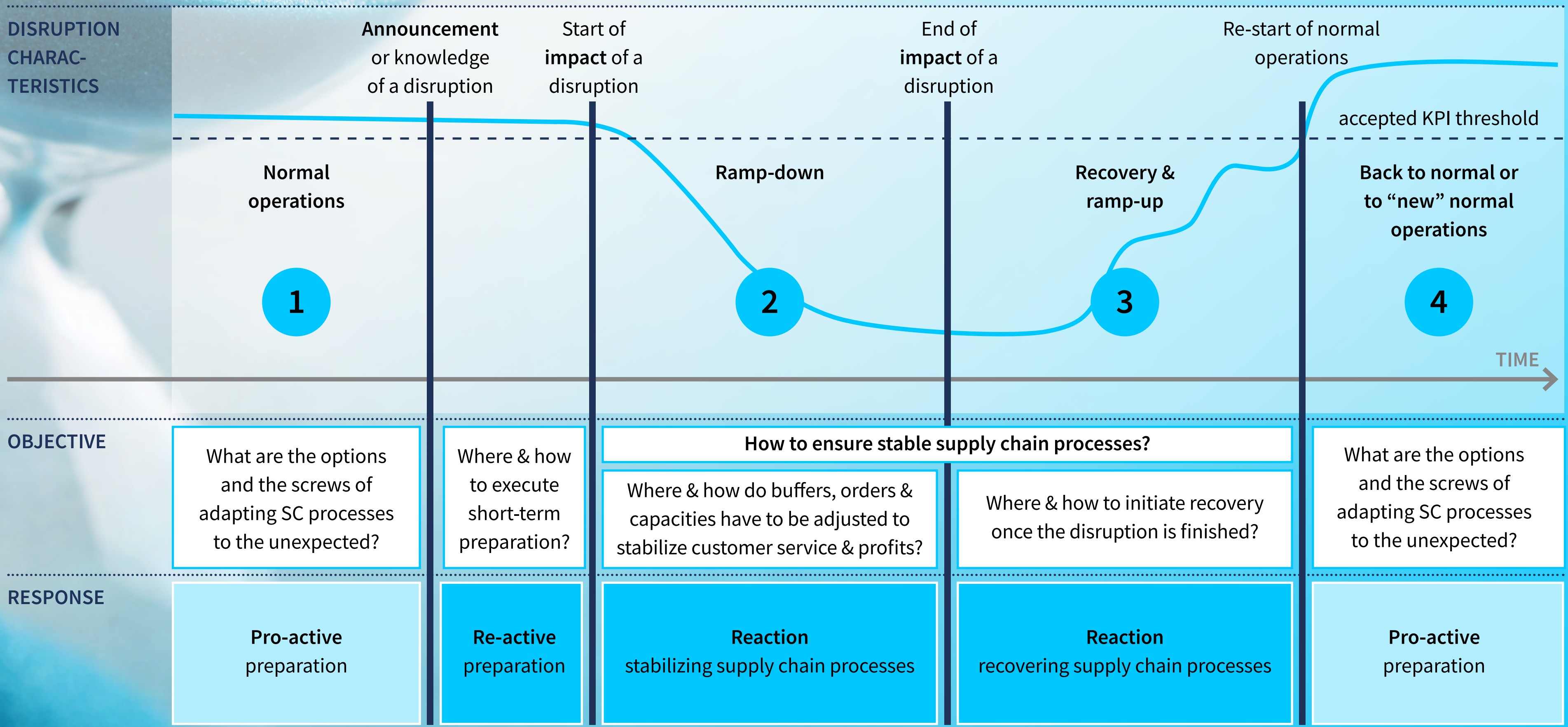
3. As long as the disruption persists, processes have to be stabilized, i.e. identifying where and how buffers, orders and capacities have to be adjusted to stabilize customer service and company's profit. Next, as soon as a disturbance weakens, recovery must be initiated. i.e. raising production capacities. The sequence and the extent of ramp-up processes must be carefully determined.

4. When a disruption is over and normal or "new" normal operations resume, again the supply chain is under evaluation and needs to be constantly tracked and adapted in order to prepare for the next "unknown".

In order to make reliable and resilience-increasing decisions, each phase requires the capability to identify and assess vulnerabilities.

Prior to determining risk measures, i.e. deciding which type of risk measure is right and how to design it, the underlying supply chain interdependencies need to be recognized, so that the uncertain environment can be understood. Finally, this knowledge can be applied to resilient model formulations and processes.

DISRUPTION PROFILE WITH CHARACTERISTICS AND CORRESPONDING RESPONSE PHASES



The Path to Resilience: Quantitative Risk Sensing

Although the challenge is understood by many companies, the path to resilience remains uncertain. Real decision making for supply chain resilience needs quantification: for example, what is the impact of an increased risk stock on my profit margin? By how many units should the risk inventory be increased for a particular product at a particular location? How should an limited "budget" for risk mitigation be spent, on which products/locations should buffers best be distributed? What is the benefit in terms of service level increase of an additional supplier once my supply chain is disrupted? What are the related costs?

In this context, Quantitative Risk Sensing is a framework that makes use of diverse analytical methods like simulation, optimization and machine learning to quantify both vulnerabilities in terms of corporate objectives as well as resilience measures. Its overall objectives are:

KEY OBJECTIVES

- **Understand vulnerabilities of supply & distribution network**
- **Accept & incorporate uncertainty in decision modeling for continuous planning and design**
- **Anticipate future developments and determine efficient mitigation measures**

The Quantitative Risk Sensing Framework

Identify causalities, i.e. determine causes and their related effects on supply chain performance

The identification of causalities compared to the identification of correlations is particularly important in order to really capture the originator and not the forwarding or recipient of a vulnerability or a parallel effect that is independent of the identified vulnerability. For example, the COVID-19 pandemic has caused a demand and supply shock. Demand and supply shock are correlated, but the supply shock is not the trigger for the demand shock. The cause-and-effect analysis starts with preparing and gathering data, followed by the execution of structural learning algorithms that are enhanced by relevant domain expertise of decision makers. Causalities are identified by the means of graphical and statistical modeling.

Conduct a structural analysis to identify vulnerable parts in the network structure

This step of the overall Quantitative Risk Sensing framework determines both vulnerable and resilient infrastructure, like nodes (e.g. production sites, supplier, warehouses), links (e.g. transportation modes) and connected, small supply chain snapshots. This analysis step is not (or not only) about identifying the bottleneck infrastructure like critical paths, but about understanding the structural capabilities of the underlying network in a static environment. This knowledge will be used later to formulate better – that is resilient – decision models.

Evaluate existing uncertainties of supply chain parameters

Evaluating uncertainties of relevant parameters does not imply quantifying the probability of a disruptions. This step rather focuses on the quantification of the uncertain and thus potential development of relevant supply chain parameters. Most often, the available data on potential development is rather limited, but decision makers are usually capable of providing "some" information, e.g. they can provide a range of potential values for capacities or lead times.

Identify the interdependencies of supply chain parameters and their impact on supply chain performance

The previous three steps provide the basis for the analysis of process dynamics, which is dedicated to the assessment of criticality and interdependencies of supply chain processes. What processes are critical for our supply chain goals? How critical is their influence on relevant KPI? To do so, different scenarios need to be simulated, in which the future development of supply chain parameters, like production capacity, is anticipated.

The objective of these so-called what-if scenarios is to determine the time-to-sustain: How long can reduced capacity be sustained before a critical service or break-even point is reached? In addition, a so-called "backward what-if" scenario analysis can be performed. Most supply chain officers know what they do not want to become effective, e.g. a drop of more than 5% service reduction or more than 4% cost increase. It is therefore advisable to first clarify the threshold value of the service or cost, to use simulation approaches and start the scenario-based analysis that identifies those scenarios, i.e. the development of processes that would lead to the deterioration below previously defined KPI threshold.

Focus on resilient decision making, which includes vulnerability reduction and stochastic decision making

The objective of vulnerability reduction is of course to prolong the time-to-sustain and to stabilize the impact on gross margin. At the same time scenario-based simulation approaches make the assessment of different, pro-active as well as re-active mitigation options possible. The ultimate goal of supply chain risk management is to make supply chains (more) resilient. Stochastic decision-making incorporates uncertainty in the decision model and allows to optimally balance customer service and company profit while eliminating the worst potential outcomes and accepting investments needed for resilience measures.

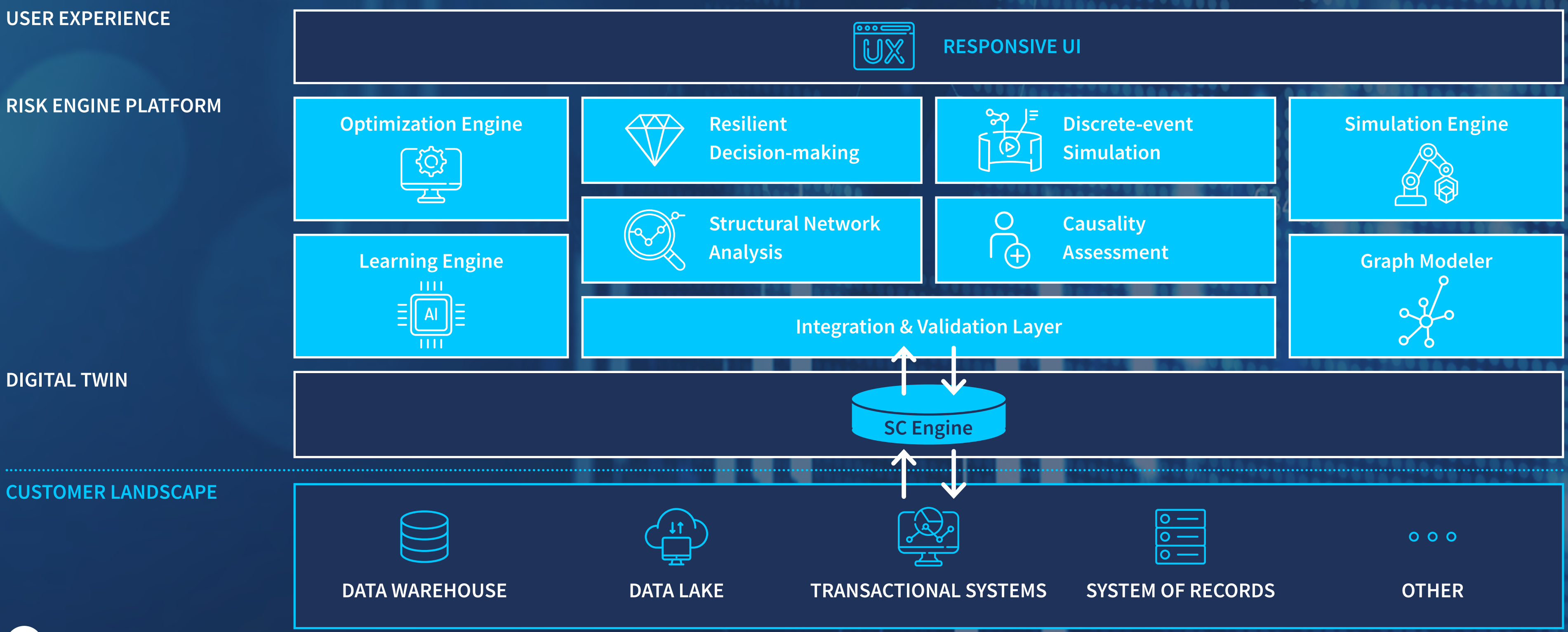
Steps and related methodologies towards a continuous supply chain risk management

Conclusion: From Concepts to Solutions

Supply chain risk is dynamic, because business and supply chain environments are. The analysis and decision-making must adapt to the dynamic environment and be carried out continuously. A high-level application solution can provide the previously described analysis. It consists of three different layers: a digital twin of the underlying supply chain that represents relevant supply chain processes and provides the basis for the modules incorporated in the risk engine platform, namely optimization-, simulation- and learning-engine as well a graph modeler. By the support of these engines, Quantitative Risk Sensing can be conducted. A responsive user interface captures decision makers' risk attitude and offers visual support for analysis results.

Quantitative Risk Sensing combines numerous methodologies such as machine and statistical learning, scenario-based simulation and stochastic optimization. The objective is to uncover hidden vulnerabilities, reduce them and prepare for the upcoming unexpected events as well as to continuously build resilience into the daily decision making process.

HIGH-LEVEL APPLICATION VIEW FOR A QUANTITATIVE RISK SENSING FRAMEWORK



Camelot Management Consultants

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Why Camelot

- Camelot effectively connects innovative supply chain concepts, digital technologies, and analytics to build superior and resilient supply chains for our clients.
- Supply Chain Management is one of Camelot's core capabilities. Clients and analysts alike have acclaimed the excellent quality and innovative nature of our conceptual thinking as well as our ability to execute.
- We are a group of practitioners with deep, first-hand understanding of industry trends. Our consultants are sought advisors for supply chain transformations in our core industries.

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