# MANAGING RISK BETTER, FASTER, AND SMARTER WITH DIGITIZED SUPPLY CHAINS

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*The application of diverse technologies such as sensors, artificial intelligence, cloud computing, digital twins, and predictive analytics is rapidly changing the way companies design, manufacture, distribute, and service products. An obvious indication of this change is the increasing evolution toward digitized supply chains, which support the rapid integration of data and information from different sources to enhance supply chain performance. This article explores digitization as a critical enabler of effective supply chain management, including risk management.*

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The application of diverse technologies such as sensors, artificial intelligence, cloud computing, digital twins, and predictive analytics is rapidly changing the way companies design, manufacture, distribute, and service products. It is also changing how they perceive and manage supply chain risk. The culmination of these changes, sometimes referred to as the fourth industrial revolution, or Industry 4.0, is causing disruptions that blur the line between the digital and physical worlds.

An obvious indication of this change is the increasing evolution toward digitized supply chains, which allow for the integration of data and information from different sources and locations to enhance supply chain performance. Traditional value chains are evolving into value networks that are characterized by their ability to send and receive data and information to and from any point in a firm's ecosystem to better meet shifting market conditions and unlock new forms of value.

This article explores digitization as a critical component of effective supply chain management, including risk management. We first explore supply chain digitization as a concept and explain the logic underlying digitized supply chains. Next, a synopsis of emerging tools and techniques that are part of the digital world appears followed by the critical linkage between digitization and a firm's ability to evolve along a risk maturity continuum. We conclude with guidance about how an organization can move forward in its quest to digitize its supply chain.

## WHAT IS SUPPLY CHAIN DIGITIZATION?

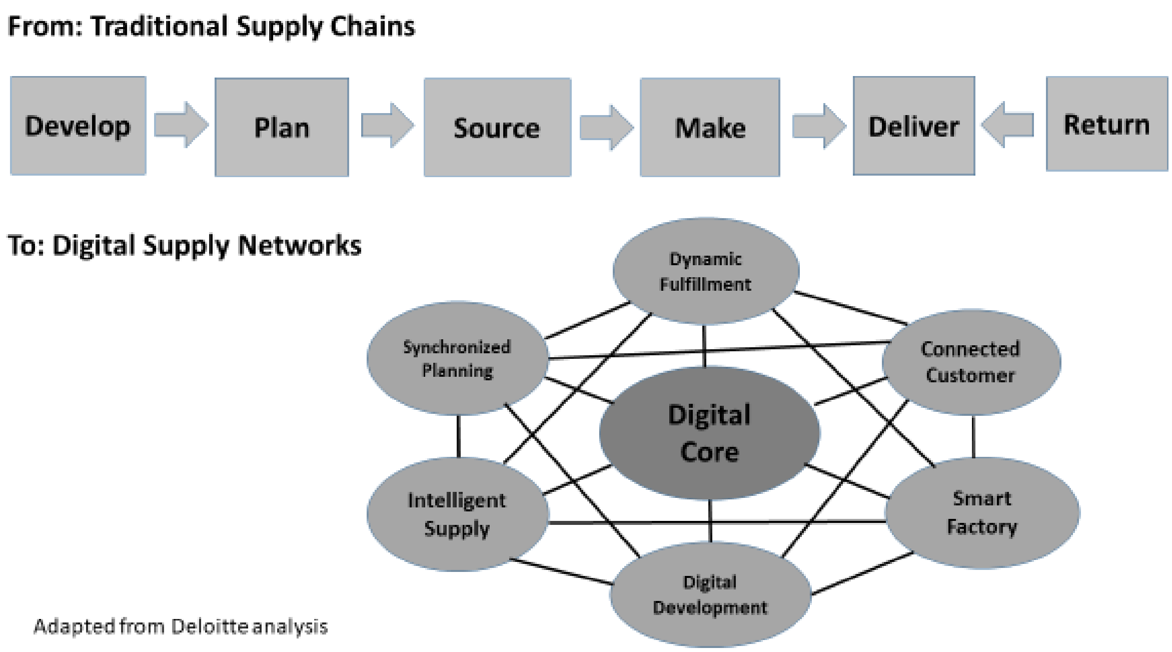
Supply chain digitization is presented in sometimes different but conceptually similar ways. At its most basic level digitization simply involves converting something to digital form. In terms of a supply chain, digitization reflects a movement toward a "completely integrated sequence of planning and production solutions that work in tandem to create a more visible supply stream across each touch point of the value chain."[1] Most experts view digitization as is the culmination of changes involving the digital evolution of the supply chain, sometimes referred to as the fourth industrial revolution, or Industry 4.0. As mentioned, these changes are causing disruptions that blur the lines between digital and physical supply chain worlds.[2] Applications such as Big Data; artificial intelligence and machine learning; digital twins; predictive analytics; sensors; additive manufacturing; cloud computing; and other data storage and management platforms provide supply chain visibility and transparency at unprecedented levels.

Most supply chains feature a series of discreet, sequential steps involving marketing, product development, manufacturing and operations, distribution, and eventually customers.[3] Digitization alters this model dramatically by removing barriers and creating a completely integrated ecosystem that is fully transparent to all the players involved through the use of key digital technologies.

A concept associated with digitization is something called digital supply networks (DSN's), which at this time is closer to theory than accepted practice. According to Deloitte, Digital Supply Networks are traditional, linear supply chains and their nodes that are collapsed into a set of networks, thereby becoming a source of increased differentiation between firms.[4]

DSNs allow for the integration of data and information from diverse sources to drive the physical production and distribution of manufactured goods up and down the supply chain. They are flexible, interconnected matrix-type structures that allow data and information to move non-linearly to maximize efficiency under changing market conditions. Traditional supply chains are transitioning toward value networks that, at least conceptually, allow organizations to send and receive data and information to or from any point in their widely diverse supply chains. Research by Deloitte revealed that almost 70 percent of firms studied believe DSN's will eventually provide them with significant or exponential benefits.[5] Figure 1 presents a conceptualization of the shift from traditional supply chains to an interconnected matrix that allows data and information to move non-linearly.

**Figure 1**
**Moving from A Traditional Supply Chain to Digitized Supply Networks**




Supply chain digitization is often presented as essential for ensuring future supply chain effectiveness. In reality, barriers and constraints are present that make a comprehensive digital transformation a challenge.[6] A study by Deloitte evaluated a comprehensive set of potential barriers and challenges to implementation, with almost all clustering around a narrow statistical range in terms of importance. In other words, no subset of barriers or challenges stands out or separates from other barriers. This means that many rather than few barriers and challenges affect the implementation of digitization.

At a macro level, two major hurdles are present when looking to digitize the supply chain. First, realizing the value proposition of digitization requires breaking down cross-organizational silos and collaboration barriers, which is no small task when dealing with numerous internal and external customers, carriers, suppliers, production facilities, and logistics hubs.[7] Second, a profusion of technologies and platforms means that arriving at agreed-upon solutions (and solution providers) that can be integrated into an accessible, shareable, and even standardized system or network poses some interesting challenges.

What we are witnessing today are applications that focus on specific digitization objectives within the supply chain (for example, blockchain). As with other major transformations, whether this involves Lean, Six Sigma, or risk management, we often see a "pockets of excellence" evolution whereby parts of an organization have mastered some narrow aspect of a broader implementation. This implementation, however, is not yet widespread and/or comprehensive in its scope. The pockets are usually discreet or local rather than cross-organizational and comprehensive. This tends to characterize the state of nature today in terms of digitization.

## THE LOGIC OF DIGITIZED SUPPLY CHAINS

A primary driver behind a digitized supply chain is to create a responsive, agile, and transparent supply network that can adapt quickly to unknown variables. These variables can include sudden demand changes that affect forecast and inventory levels, modifications to orders, risk events, and unplanned changes to resource availability. When implemented properly, digitization is a key enabler of a resilient enterprise. Resilience refers to the ability of an organization to recover from or adjust to misfortune or change. It is also what allows an organization to "bounce back" from a risk event.

An organization that has a digitally-transformed supply chain should have improved risk management capabilities, reduced supply chain costs, shortened lead times, and improved data reporting and analysis capabilities. Digitization allows companies to not only analyze large amounts of data in real-time or near real time, it also allows the sharing of data seamlessly with other supply chain members to help avoid bottlenecks or constraints at critical stages in the planning and production process.[8] At a more detailed level, Accenture conducted a study globally across multiple industries that evaluated the benefits derived from combining digital modeling, Big Data, and analytics. Some key findings include:

- 50 percent of study participants indicated improvements in customer service and demand fulfillment of more than 10 percent
- Just over 40 percent said they experienced faster and more effective reaction time when solving supply chain issues
- Just over 35 percent said they increased their supply chain efficiency by more than 10 percent
- Just over 35 percent said they experienced greater integration across the supply chain
- A third said they optimized inventory and improved asset productivity, and
- Almost 30 percent indicated they significantly improved their cost-to-serve their customers

Interestingly, research reveals that no unique benefit or set of benefits separate themselves from a broader list of potential benefits.[9] The conclusion here is that digitization potentially offers an array of benefits that are largely a function of a firm's desired objectives or are influenced by what part of the supply chain is being digitized. When implemented properly, supply chain digitization should provide benefits that justify the time and resources required to make digitization, however it is operationalized within a company's supply chain, a desired reality.

## THE TOOLS AND TECHNIQUES—THE FOUNDATION OF DIGITIZATION

An abundance of tools and techniques fall under the umbrella of supply chain digitization. Some are more mature while others are evolving and have yet to come anywhere close to fulfilling their potential. One study evaluated close to 20 technologies that are part of the domain of digitized supply chains.[10] Moving from a proverbial "grab bag" of technologies to the crafting of an integrated system that aligns with agreed-upon objectives across the supply chain will require serious resources, commitment, and leadership. The following summarizes some of the more promising digitization technologies from that "grab bag."

**Blockchain.** At its most basic level a blockchain is a distributed digital ledger. It is a system in which a record of transactions is maintained across computers that are linked in a secure and peer-to-peer network. Blockchain systems allow digital information to be distributed but not copied. This technology was developed initially to support transactions and to show ownership for cryptocurrencies such as Bitcoin. It is now evolving to potentially become a major part of supply chain risk management. The blockchain is an incorruptible digital ledger of economic transactions that can be programmed to record not just financial transactions but virtually everything of value.

How does blockchain support the supply chain? In 2018, a series of foodborne illness outbreaks—including E. coli in romaine lettuce and Salmonella in eggs, breakfast cereals, raw turkey and other products—sickened hundreds of people in the United States and caused costly product recalls. In response, Walmart announced that it had asked suppliers of leafy green vegetables to begin implementing blockchain technology to trace their products back to the farm. It can take up to seven days to track where a product came from with the traditional paper-based ledgers used by most farms, packing houses, and warehouses. By applying blockchain technology, companies are able to identify the source of contamination or other issues almost immediately. Eventually, Walmart anticipates that customers will be able to scan bags of salad and know its exact origin, potentially offering greater peace of mind. This also offers considerable financial benefits because it reduces the costs of recall programs and other risk liabilities.

Bühler Group, a provider of grain processing machinery used to process an estimated 65 percent of the world's grain, is also pursuing blockchain technology. A pilot project provided customers—grain, flour, rice and corn millers—with transparency about the origins of the grains they are purchasing. Digitizing the food safety process reduces reputation and legal risk not only for Bühler but for other participants in the supply chain, such as farmers, haulers, and shopkeepers by allowing them to identify and isolate sources of contamination.

Whether or not one has an opinion regarding blockchain, there are pilot programs running across multiple industries, many supported by IBM and other large manufacturers. A few examples include:

- Automotive: Full track and trace of bill-of-material parts from pre-production to sale along with spare parts management
- Cyber security: Tracking, tracing, identification of threats and data integrity algorithms
- Medical supply chains: Track and trace of products, anti-counterfeiting, personal data management and integrity along with securing payment transactions
- Banking financial FinTech: credit history, energy, forecasting, insurance and IoT
- Food supply chain: Tracking of raw materials such as vanilla and palm oil from the source to the ultimate customer
- Energy: Decentralizing energy transfer and distribution is now possible via micro-transactions of data sent to blockchain, validated and then re-dispersed to the grid while securing payment to the submitter
- Customs clearance: An example of a data platform is TradeLens, which was launched to help modernize the world's supply chain ecosystems. This platform enables participants to digitally connect, share information, and collaborate across the shipping supply chain ecosystem

**Predictive Analytics and Big Data.** Most people have heard the term predictive analytics. It is a popular concept that has received a great deal of attention, both from practitioners and academics, as a way to better manage supply chains. Predictive analytics is the branch of advanced analytics that uses data to make predictions about unknown future events. It utilizes many techniques, including data mining, statistics, modeling, machine learning, and artificial intelligence to analyze current data to make predictions about the future. Other descriptors that are used when referring to predictive analytics include Big Data, business intelligence, data analytics, and business analytics. A defining characteristic of predictive analytic techniques is they rely on data and mathematical models. These models utilize algorithms that use input variables to arrive at a response or output variable.

Predictive analytics is part of an analytical hierarchy that ranges from basic to more advanced. Various types of analytics represent levels along a continuum:

- **Level One: Descriptive Analytics**. Descriptive analytics describe the basic characteristics of a data set, such as mean, mode, and standard deviation
- **Level Two: Diagnostic Analytics**. Diagnostic analytics are characterized by techniques such as data discovery, data mining, and correlations. Diagnostic analytics takes a deeper look at data to understand the causes of events and behaviors
- **Level Three: Predictive Analytics**. Predictive analytics are forward looking and seek to identify what will happen at some future time, often by generating predictive scores or probabilities for individual events. This is increasingly part of supply chain risk management
- **Level Four: Prescriptive Analytics**. Prescriptive analytics involve the use of technology, such as artificial intelligence, to help businesses make decisions through the analysis of data. It factors information about possible situations or scenarios, available resources, past performance, and current performance, and suggests a course of action or strategy

Tools and techniques that provide predictions, such as regression modeling and "what if" scenario planning, have existed for years. The relevance of predictive analytics has increased along with the amount of data being captured from people (such as on-line transactions and social networks) and sensors (such as GPS mobile devices) as well as the availability of cost-effective processing power, whether it be Cloud or Hadoop-based.

Specifically, how do today's predictive analytical techniques differ from traditional predictive approaches? First, the analytical tools available today are more rigorous. Hadoop, for example, is an open-source, java-based software framework for storing data and running applications on clusters of commodity hardware. This hardware provides massive storage for any kind of data, enormous processing power, and the ability to handle virtually limitless concurrent tasks or jobs. A second difference between advanced and traditional predictive tools pertains to structured versus unstructured data sets. Structured data refers to data that resides in a fixed field within a record or file. This includes data contained in relational databases and spreadsheets. Unstructured data sets include information that either does not have a pre-defined data model or is not organized in a pre-defined manner.

What else is different? The sheer volume of data separates traditional from emerging predictive analytic approaches. Predictive analytics increasingly relies on big data sets. Big Data is a term that describes extremely large data sets that may be analyzed computationally to reveal patterns, trends, and associations, especially relating to human behavior and interactions. Finally, predictive analytics often rely on real-time versus stored or batched data. Real-time data does not mean that end users receive the data instantly since any number of bottlenecks can affect the data collection infrastructure, such as the bandwidth between various parties or the slowness of the end user's system.

Real-time data is enormously valuable in all sorts of analytics projects and for keeping people informed through the power of instant or near-instant data delivery. With the proliferation of mobile devices and other advancements in technology, including the Internet of Thing (IoT), it is becoming common for software to simply forward collected data directly to end users. Immediate alerts, for example, might be issued to relevant parties when a cargo vehicle deviates from its expected route or remains idle for too long.

**The Internet of Things.** It would be incomplete to talk about predictive analytics without a discussion of the Internet of Things (IoT). Defined formally, the IoT is a system of interrelated computing devices, mechanical and digital machines, objects, animals, or people that are provided with unique identifiers (UIDs) and the ability to transfer data over a network without requiring human-to-human or human-to-computer interaction.

The IoT is comprised of a sensor network of billions of smart devices that connect people, systems, and other applications to collect and share data. It is a key enabler in the generation and collection of the massive data that supports predictive analytics and artificial intelligence. A "thing" in the IoT can be a person with a heart monitor implant, a farm animal with a biochip transponder, an automobile that has built-in sensors to alert the driver when tire pressure is too low, a truck that transmits data about engine performance, or any other natural or man-made object that can be assigned an IP address and is able to transfer data over a network.[11]

Kevin Ashton, co-founder of the Auto-ID Center at MIT, first mentioned the Internet of Things in a 1999 presentation made to Procter & Gamble. Since that time the Internet of

Things has evolved over time due to the convergence of multiple technologies, real-time analytics, commodity sensors, machine learning, and embedded systems. This convergence has eliminated barriers between operational technology and information technology, enabling unstructured machine-generated data to be analyzed for insights that enable improvements and predictions.

The IoT is a natural extension of supervisory control and data acquisition (SCADA). SCADA is not a specific technology per se but rather a type of application. It is a category of hardware and software application programs for process control and the gathering of real-time data from remote locations for the purpose of controlling equipment and conditions. It is also an enabling technology that will support capabilities that have not even been considered. Hardware gathers and then feeds data into a computer that has SCADA software installed where it is then processed. Later-generation SCADA systems developed into first-generation IoT systems. The total installed base of Internet of Things (IoT) connected devices is projected to be 75 billion worldwide by 2025.[12]

**Artificial Intelligence.** A major topic today, and one where the hype has not always matched the reality, is artificial intelligence. Artificial intelligence (AI), also referred to as machine intelligence or machine learning, is intelligence demonstrated by machines, which is in contrast to the natural intelligence demonstrated by humans. With improvements in storage, processing speeds, and analytic techniques, AI algorithms are becoming increasingly capable of sophisticated decision making. Financial algorithms, for example, can spot extremely small differentials in stock valuations and carry out transactions that take advantage of that information. Environmental sustainability systems use sensors to determine whether someone is in a room and automatically adjusts heating, cooling, and lighting based on that information. Perhaps the true contribution of AI will be its ability to make faster and better decisions than humanly possible. An example relates to AI-enabled technology winning at games that require significant mental prowess, such as chess.

Part of the challenge when discussing artificial intelligence is a lack of a uniformly agreed upon definition.[13] Alan Turing, who was an English mathematician, computer scientist, logician, cryptanalyst, philosopher, and theoretical biologist, is credited with the origin of this concept when he speculated in 1950 that "thinking machines" will eventually reason at the level of a human being. He created his "Turing Test," which specifies that computers must be able to complete reasoning puzzles as well as humans in order to be considered "thinking" in an autonomous manner.

To qualify as an artificial intelligence system, the system must possess three distinct characteristics: intentionality, intelligence, and adaptability.[14] Unlike passive machines that are capable only of mechanical or predetermined responses, AI enabled machines rely on sensors, digital data, or remote inputs from different sources to analyze data instantly and to act on insights derived from the data. Humans design these systems with the *intention* they will arrive at conclusions based on instant analysis. Humans determine intentionality; the machines do not make that determination.

AI is often combined with machine learning and predictive analytics to provide *intelligence* that supports better decision-making. Computer programmers must develop intelligent algorithms that compile decisions based on a number of different considerations. Machine learning searches for underlying trends from collected data using these intelligent algorithms. If the data are relevant for addressing a practical problem, software engineers can combine that knowledge with data analytics to better understand specific issues.

The ability of AI systems to learn and adapt as they compile information and make decisions is called *adaptability*. Artificial intelligence systems must adjust as circumstances or conditions shift. Examples include alterations in financial situations, road conditions, or environmental considerations. AI must integrate these changes in its algorithms and make decisions on how to adapt to new possibilities. Autonomous vehicles, for example, can use machine-to-machine communications to alert other vehicles on the road about upcoming congestion, potholes, highway construction, or other traffic impediments.

How will artificial intelligence benefit supply chains and risk management? AI should support supply chain improvement in various areas, each of which has the potential to reduce supply chain risk. These areas include:[15]

- **Streamlined Processes**. As AI oversees the handling of supply chain processes, the system can learn to adapt to changing scenarios. By using historical data and trends, AI-enable systems will be able to streamline every aspect of processes from demand to inventory to supply in order to best serve the needs of customers. This would be done with minimal human input, saving time and reducing errors. Also, due to the vast amount of data and memory available, AI systems will learn from past mistakes and ensure risk-free paths are undertaken
- **Near Perfect Planning**. A major cause of excessive risk in a supply chain is poor planning, often because of incomplete or untimely data. One aspect of planning that can be constraining involves adhering to certain parameters because of data limitations, a constraint that would not affect AI systems. By using massive sources of information simultaneously, AI systems could alter demand schedules depending on a variety of trends, including weather, customer demand patterns, traffic, supplier capacity, etc., within a minimal time and with a near zero error rate. The ability to plan better can also mitigate the impact of the Bullwhip effect
- **Market Shaping**. By using continuous feedback from customers alongside extensive sources of market information, AI can not only assist with supply chain processes but also with product designs. Product designs can also be linked to various supply and production elements such as raw material availability, lead times, and supply and operating capacity to ensure optimal design parameters
- **Faster and More Accurate Transportation**. AI can be used to optimize transportation linkages across the supply chain. Automotive and technology companies have been exploring driverless vehicles for a number of years, as mentioned earlier. AI can also be used to support dynamic routing of shipments and vehicles, something that can improve delivery accuracy, decrease lead times, reduce transportation costs, reduce production shutdowns, and reduce human labor costs
- **Monitoring of Corporate Social Responsibility Issues**. AI can be used to monitor local and social media news services around suppliers to search for issues such as the use of poor labor practices and environmental issues. It can even be used to identify likely links between parties at the lower tiers in supply chains which in turn might expose the buying organization to risk

- **Better Integration of Financial Performance with Supply Chain Optimization**. AI allows on-going improvements in supply chain investments to be measured and recorded for further improvements to be implemented in near real time

Whether the hype surrounding artificial intelligence eventually matches the reality of artificial intelligence remains to be seen.

**Digital Twins.** Digital twins are digital replicas of a living or non-living physical entity. By bridging the physical and the virtual world, data is transmitted seamlessly allowing the virtual entity to exist simultaneously with the physical entity. Digital twin refers to a digital replica of potential and actual physical assets, processes, people, places, systems, and devices that can be used for various purposes. The digital representation can provide both the elements and the dynamics of how an Internet of Things device operates throughout its life cycle. Definitions of digital twin technology emphasize two important characteristics. First, each definition emphasizes the connection between the physical model and the corresponding virtual model or virtual counterpart. Second, this connection is established by generating real time data using sensors or similar means. Digital twins can integrate the Internet of Things, artificial intelligence, machine learning, and software analytics with spatial network graphs to create living digital simulation models that update and change as their physical aspects change. Of the 250 exemplar companies in terms of supply chain risk management that we are aware, almost all have analyzed their supply chains using digital twins and computer models.

## A Case Example of Making Supply Chain Digitization a Reality

Air Products, a producer of industrial gases, has developed sophisticated processes to separate air into its component elements of nitrogen, oxygen, and argon. It is also a company that has digitized an important part of its supply chain to manage remotely the inventory stored at its customer locations, ensuring that its customers never run out of supply. Running out of oxygen can be catastrophic to a hospital that relies on a steady flow of that element to service its patients.

A major innovation that has helped Air Products manage not only its own supply chain, but also its customers, is digitization through remote telemetry. (Related to telemetry is a technology called telematics). Telemetry is the science or process of collecting measurements or other data at remote points and then automatically transmitting that information to receiving equipment for monitoring and analysis. Air Products has attached telemetry units to every storage tank across its vast customer network to track inventory levels and product usage. Besides improving service and removing the transaction costs associated with ordering and replenishing inventory, remote telemetry allows Air products to employ advanced algorithms to optimize its daily network of customer deliveries.

Data from storage tanks is transmitted directly to Air Products daily, thereby allowing the company to track usage rates and forecast expected customer inventory levels. Using usage data originating from the customer as well as replenishments that are triggered when an on-hand quantity reaches a reorder point, Air Products can ensure the uninterrupted flow of gas through its delivery network.

The certainty provided by digitization allows inventory levels in tanks to move lower than is historically the case before triggering a replenishment delivery. The result is a less frequent need to fill customer tanks, which means fewer deliveries and lower average inventory levels, and therefore lower inventory carrying charges for customers. Customers also benefit from having Air Products manage their inventory levels while seamlessly scheduling replenishment deliveries. This allows customers to focus on what they do best without worrying about supply disruptions.

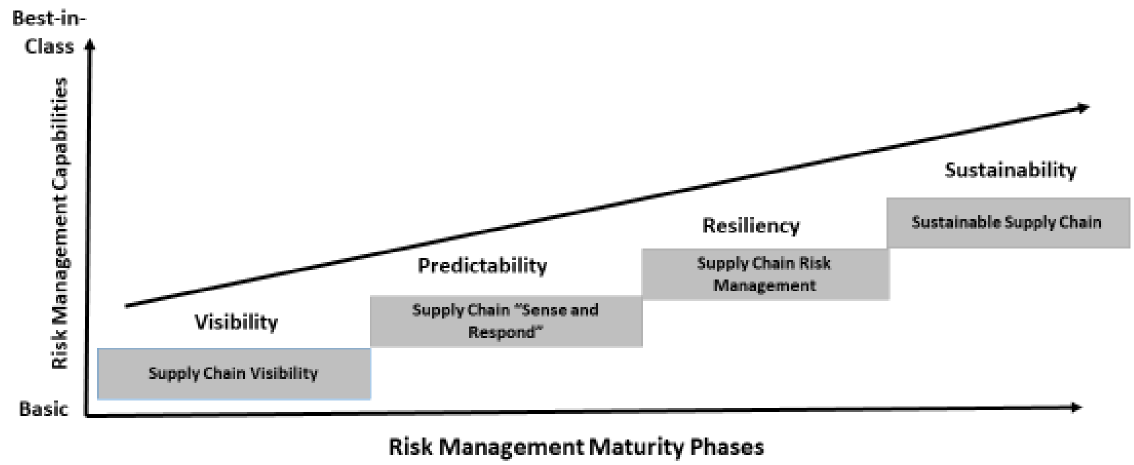
Supply chain digitization helps Air Products manage risk through exceptional customer service as it simultaneously removes waste from the supply chain. This system helps customers better manage their working capital while Air Products optimizes its distribution costs. Remote telemetry data combined with predictive algorithms has altered dramatically the way this company manages the downstream portion of its supply chain.

When a company's product is a pure commodity, as is the case here, differentiation often occurs through services. Otherwise, a non-differentiated company faces a bleak future competing primarily on price. Here, a vendor managed inventory system that is supported by digitization and predictive analytics is helping to manage not only supply chain risk, but also business risk. Relying on a system that eliminates product interruptions to customers is a differentiating factor that can separate one company from another. The capabilities enabled by supply chain digitization help Air Products win and retain customers.

## DIGITIZATION AND A RISK AND RESILIENCY MATURITY MODEL

The logic behind digitizing the supply chain becomes clearer when framed within the context of a risk and resiliency maturity model. Supply chain digitization is a key enabler that supports an organization's growth along a four-phase maturity continuum. Figure 2 presents a model that represents an evolutionary journey through phases that are reactive or basic to optimized, integrated, and advanced in terms of risk management maturity. Since supply chain management is constantly evolving as new ideas, solutions, and approaches are emerging, central to success will be the ability to build expertise and knowledge that allows a company to differentiate itself from competitors. Also central to success is the ability to anticipate, assess, and manage supply chain risk. The following summarizes the risk maturity model.

**Figure 2**
**21st Century Supply Chain Management Risk Maturity Model**




Source: Supply Chain Risk Management Consortium

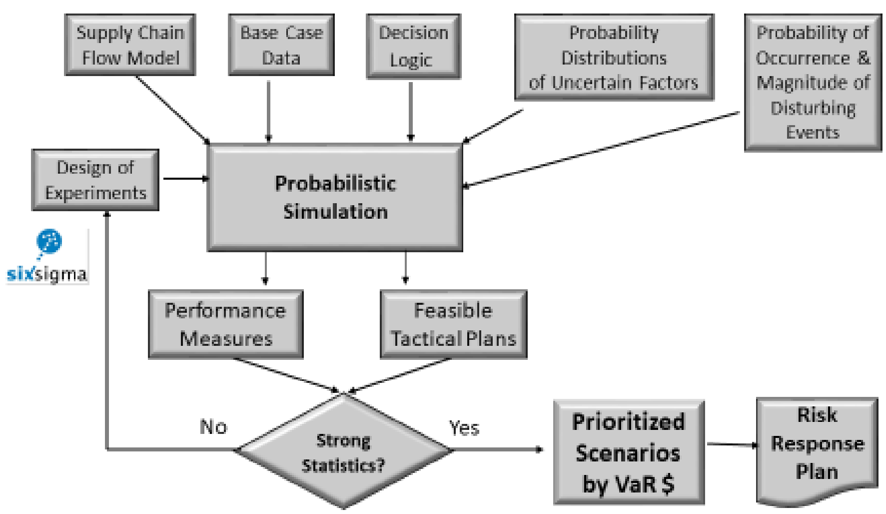
**Visibility**. The first stage of the Supply Chain Management Maturity Model refers to visibility. Awareness of risk and risk events across the supply chain is an important first step within the risk management journey. This also relates to knowing, preferably in real or near real-time, the location of materials and assets, such as inventory and personnel. Some refer to this type of visibility as supply chain transparency. Most companies begin their risk journey using tools such as third-party supplier assessment tools and web-based heat maps that evaluate risk across the entire supply chain. In this phase organizations are starting to map and digitize their supply chain in an effort to better manage demand and supply disruptions faster and more effectively than competitors. An ability to become aware and respond more quickly than competitors to unexpected events is a critical factor defining supply chain excellence, something that cannot happen without supply chain visibility. Unfortunately, what you don't know about your supply chain can and will hurt you. Mapping the supply chain and capturing vital data along that chain is a critical factor when creating a resilient enterprise.

Improving supply chain visibility also involves leveraging global risk alert solutions, usually from third-party providers. These providers scan the globe every 30 minutes and capture, analyze, and categorize reams of data. They use this data to create electronic bit maps and send risk alerts to their clients, who then superimpose the bit maps over their global digital supply chain maps. Companies such as Bayer Crop Science take the bit maps and produce concentric circles superimposed on their digitized supply chain maps to evaluate threats to their operations or to other supply chain members. Eminent threats, such as adverse weather, can cause Bayer to activate its risk response plans. The ability to identify a threat and then quickly respond can save lives and ensure business continuity. Visibility supported by digitized supply chain solutions are central to success here.

**Predictability**. As companies mature in terms of risk and resilience, they begin to leverage their visibility capabilities to test their supply chains through "what-if scenario planning." These exercises, using network optimization and probabilistic modelling and mapping tools, provide a view into how supply chains might react to risk events, including demand and supply disruptions. This insight helps companies create risk response plans.

Stress testing, which some refer to as scenario planning, is a technique widely used in financial institutions – indeed it is mandatory for these institutions as a matter of compliance. It is largely voluntary when applied to supply chain risk management unless it is within a relevant regulated environment. When applied to supply chains, stress testing involves computer simulation techniques used to test the resilience of a supply chain or network through scenario planning. As a concept, stress testing is a sophisticated digital approach to supply chain and risk management. Companies such as DuPont, Bayer Material Science, Flextronics, Nokia, Ericsson, and IBM routinely take a data-driven approach when stress testing their supply chains. Figure 3presents a flow model for stress testing supply chains.

**Figure 3**
**Scenario Planning and Supply Chain Stress Testing**




Source: Supply Chain Risk Management Consortium

An example of digital modeling and stress testing involves a large pharmaceutical company that produces and distributes antibodies for children. Historically, this company's biggest issue involved its inability to identify, assess, and mitigate supply chain disruptions, something that caused product availability shortages. Using digital tools this company developed an end-to-end model of its global supply chain; ran discrete-event simulations for scenarios across known and unknown supply chain risks; and ran sensitivity analyses for every scenario to validate the statistical strength of each outcome to pinpoint the maximum efficacy of each scenario. This process resulted in a more robust planning capability across its supply chain; a more proactive methodology to quickly identify and mitigate supply chain risks; and improved on-time delivery of antibodies to children around the world.

**Resiliency.** Companies within the resilience stage are building upon their organizational infrastructures through corporate frameworks while instituting new performance indicators such as Time-to-Recovery (T-t-R), Value-at-Risk (VaR), Resiliency Indexes, bankruptcy prediction scores, and the cash conversion cycle. In this stage, companies are embedding many digitally-based tools, techniques, and tactics into their daily supply chain operations and business decisions.

Companies in this stage also leverage predictive analytics and other analytical approaches to create a culture that includes risk considerations during decision making. Leaders in this stage continually review their risk appetite and risk profile, evaluating and leveraging their knowledge to update their supply chain risk management portfolio. They also have access to real-time risk event information from third party providers and embed this information into their supply chain risk infrastructure.

Cisco has been pursuing its risk management journey for over 12 years. A key performance indicator at Cisco is its Resiliency Index. It is a risk and resiliency methodology that requires suppliers to analyse various risk scenarios, using many of the digital approaches featured here, and to quantitatively assess those risks using Value-at-Risk and other techniques. Suppliers are required to provide Cisco with an electronically-signed affidavit each quarter stating that the supplier has performed its due diligence and has committed to a Time-to-Recovery target for various risk scenarios.

**Sustainability.** Sustainability is a term with many definitions depending on the lens or prism one uses as a frame of reference. As presented here, companies within the sustainability stage are building upon their organisational infrastructures through corporate frameworks such as Enterprise Risk Management (ERM), Governance, Risk, and Compliance (GRC), and ISO risk standards. Risk management leaders are continuing to drive the business decisions utilizing their key risk indicators such as Time-to-Recovery, Value-at-Risk, and Resiliency Indexes. These frameworks, protocols, metrics, and organizational structures provide a foundation that sustains risk management excellence.

The supply chain risk and resiliency journey is one of small steps that move an organization through phases. Supply chain risk management is like any major process—it requires continuous attention and improvement. And, like any process, when left unattended it migrates toward chaos. Supply chain leaders that are further along the maturity model understand that each stage in the journey corresponds to years of focused effort.

The reality is that a company's ability to progress along a risk management maturity continuum is dependent greatly on that company's ability to digitize its supply chain. Effective supply chain organizations, including those that manage risk effectively, are information enabled. That information increasingly comes from digitized supply chains.

## MOVING FORWARD

Research reveals that less than 30 percent of firms are currently in the process of implementing digital transformation initiatives across their supply chain. Over 70 percent of firms have yet to consider implementing a digital transformation; are planning at some point to start implementation within the next year; or are prioritizing it among their strategic objectives.[16] This suggests that supply chain digitization is a long way from becoming a fully-scaled reality.

How an organization moves forward in its digitization efforts should be influenced largely by what it hopes to achieve. The list of supply chain objectives, which in reality are aspirations, is long and varied. The most common digitization objective currently being pursued is the synchronization of demand and supply planning. Other important digitization objectives include technology infrastructure improvements and the ability to conduct security or risk assessments. Proctor and Gamble, which Gartner has again identified as a Supply Chain Master, focuses its digital transformation on radically changing the way that work is done, specifically using algorithm driven, phase-in and phase-out optimization models to manage product transitions.[17] This is saving the company millions of dollars annually and allows it to reduce the time spent on supply chain planning. Generally speaking, one of the most sought after objectives from supply chain digitization is better and faster decision making.

While it is natural to think expansively, the reality is that most organizations begin their digitization efforts with projects designed to achieve specific outcomes. In transportation, this might involve gaining real-time insight into vehicle and driver performance and health. In the digitized world this involves telematics and wearable technology. Or, some companies are looking to manage driver shortages through the use of autonomous vehicles. Others use data to optimize fleet operations, including real-time adjustments to delivery routes and schedules. In risk management, systems that identify and score potential risk events improve a firm's ability and timeliness when mitigating risk. Demand and supply planners should benefit from applications that quickly sense changes in demand and supply markets, and combined with artificial intelligence systems quickly make or adjust planning decisions. And, product developers understand the importance of reducing the concept-to-customer cycle time associated with product development. They will appreciate the role that 3D printing systems, also called additive manufacturing, play when developing rapid prototypes.

Once a firm's leadership understands what they want from supply chain digitization, digitization efforts should feature financial investment analyses, commitment of required resources, the development of supporting metrics, and the application of project management teams and techniques.

**CONCLUSION**

Achieving excellence in any area does not happen because a company simply announces its desire to be excellent. Many organizations become frustrated because they lack the ability to develop the supply chain approaches and techniques that create a differential advantage. These organizations fail to recognize the importance of mastering a set of enablers that supports the pursuit of more advanced supply chain and risk management initiatives. Information technology, which includes digitized supply chains, is one of those key enablers.

Regardless of the platform or software used to support digitization, any solution should allow for the capture and sharing of information across functional groups and organizational boundaries in real or near real time. Digitization supports supply chain excellence by enabling the seamless capture, analysis, and movement of data and information across all parts of the supply chain. It also shortens the all-important time between cause and effect. A sought after result should be faster and better decision-making that enable an organization to manage and mitigate the uncertainties that are always certain to occur.

## Endnotes


[1] Syamaprasad De, from https://cpoinnovation.com/digitization-of-the-supply-chain/#:~:text=Supply%20chain%20digitization%20is%20the%20movement%20toward%20a,across%20each%20touch%20point%20of%20the%20value%20chain.

[2] Stephen Laaper, Glenn Yauch, Paul Wellener, and Ryan Robinson, Digital Supply Networks—A Digital Transformation, Deloitte, March 21, 2018.

[3] Stefan Schrauf, https://hbr.org/webinar/2017/10/digitizing-the-supply-chain.

[4] *Digital Supply Networks*, https://www2.deloitte.com/us/en/pages/operations/solutions/digital-supply-networks.html.

[5] *Digital Supply Networks*, https://www2.deloitte.com/us/en/pages/operations/solutions/digital-supply-networks.html, p. 6.

[6] Syamaprasad De, from https://cpoinnovation.com/digitization-of-the-supply-chain/#:~:text=Supply%20chain%20digitization%20is%20the%20movement%20toward%20a,across%20each%20touch%20point%20of%20the%20value%20chain.

[7] Syamaprasad De, from https://cpoinnovation.com/digitization-of-the-supply-chain/#:~:text=Supply%20chain%20digitization%20is%20the%20movement%20toward%20a,across%20each%20touch%20point%20of%20the%20value%20chain.

[8] Syamaprasad De, from https://cpoinnovation.com/digitization-of-the-supply-chain/#:~:text=Supply%20chain%20digitization%20is%20the%20movement%20toward%20a,across%20each%20touch%20point%20of%20the%20value%20chain.

[9] *Digital Supply Networks*, https://www2.deloitte.com/us/en/pages/operations/solutions/digital-supply-networks.html, p. 7.

[10] This study revealed that the top five digitization technologies that are receiving investment include advanced analytics; cloud computing; modeling and simulation; Internet of Things platforms; and optimization and predictive analytics.

[11] https://internetofthingsagenda.techtarget.com/definition/Internet-of-Things-IoT.

[12] Internet of Things (IoT) connected devices installed base worldwide from 2015 to 2025 (in billions), https://www.statista.com/statistics/471264/iot-number-of-connected-devices-worldwide/.

[13] This section adapts work by Darrell West, *What is Artificial Intelligence?* https://www.brookings.edu/research/what-is-artificial-intelligence/.

[14] Adapted from Darrell West, *What is Artificial Intelligence?* https://www.brookings.edu/research/what-is-artificial-intelligence/.

[15] Adapted from *What Role Will Artificial Intelligence Play in Supply Chain Management?* https://blog.arkieva.com/artificial-intelligence-supply-chain/.

[16] *Digital Supply Networks*, https://www2.deloitte.com/us/en/pages/operations/solutions/digital-supply-networks.html, p. 4.

[17] "Winners of 2019 FICO Decisions Awards Announced! Companies Celebrated for Analytic Excellence," FICO.com.