





# Digital supply networks transform the future

*Mastering new technologies, processes can create a competitive advantage*

By Ednilson Bernardes, Amit Sinha, Rafael Calderon and Thorsten Wuest

*Editor's note: This article is excerpted from the authors' book, Digital Supply Networks (McGraw-Hill, 2020).*

One of the topics at the forefront of current managerial thought and action has been digital transformation. A casual perusal of news outlets, professional magazines or industry leadership-oriented gatherings reveals the pervasiveness of the concept, which we conceive of as the reimagination of end-to-end business processes enabled by digital technologies to create and deliver significantly more value. Digital transformation comes in the wake of the current wave of technological progress, typically referred to as the Fourth Industrial Revolution, or Industry 4.0.

The emergence and convergence of new technologies that are intermingling the physical, digital and biological worlds characterize the Fourth Industrial Revolution (*The Fourth Industrial Revolution*, Klaus Schwab, 2017). It reflects the trend toward automation and data-driven processes where constant web connectivity augments manufacturing technologies and creates a smart system that enable visualizing the entire production process. A combination of cyber-physical systems, industrial internet of things, and cognitive and cloud computing drive the development of smart systems.

The strength of Industry 4.0 is the digital connection of the various technologies to create, share and analyze information for further, and often automated, action. The Fourth Industrial Revolution is also changing how we design and operate supply chains ("Technological Game Changers: Convergence, Hype, and Evolving Supply Chain Design," Stan Fawcett, Yao Henry Jin, Amydee Fawcett and Ednilson Bernardes, *Production Journal*, 2018).

As Industry 4.0 continues to progress, innovations and the convergence of technologies open up the possibility of designing and managing the supply network in entirely new ways. Pioneering companies are already pushing the envelope of the possible, with initiatives and capabilities such as anticipatory shipping. We witness the rise of the smart, always-on, always-connected, real-time and dynamically adaptive digital supply network (DSN).

## Digital transformation of supply networks

New technological developments and their convergence, large amounts of data and the widespread use of connected devices increasingly smaller, cheaper and mobile in personal and business contexts, all provide momen-

tum for disruption and tremendous opportunities for organizing and managing supply chains differently. We are experiencing a move toward a digital supply chain operating model. The emerging innovations can be used to create an overarching digital fabric across the end-to-end networks providing real time visibility, automation and control. Perhaps the best way to understand the transformation of traditional supply chains is to contrast them with the emergent digital supply network model.

A traditional supply chain consists of a sequence of processes and decisions and a set of actors occupying different consecutive linear stages in the chain, as illustrated in Figure 1. The procedures consist of obtaining raw materials, producing the products or services, moving products closer to the customer, delivering the final product and servicing it. More recently, another process has become essential, namely returning and recycling. In general, sales or shipment history have been used for statistically generating an initial demand forecast, subsequently finalized through a consensus process during the sales and operations planning (S&OP), with collaboration from sales, marketing, supply chain and finance teams. This process has proved quite useful in coping with uncertainty and reducing inventory levels and costs.

However, the overall supply chain archetype and decision-making procedure, such as the S&OP, follows various sequential stages and steps and can be quite long and demanding. The consensual forecast, for instance, trickles down to increasingly higher levels of detail, triggering a series of more specific planning activities and their execution, including the purchase of supplies, transportation, storage, movement, processing and subsequently fulfillment. Each of these actions drives different

entities across the supply chain, as information flows from node to node, often in stages, setting off new decisions and actions. Customer involvement in product design is typically limited to market research based on sampling to understand requirements. Customers have limited influence in customizing the product or service.

The Amazon effect, a term used to describe the impact that the digital marketplace has had on traditional forms of commerce, has dramatically changed customers' expectations and the way they shop. Consumers have become used to a practically frictionless shopping experience and almost immediate satisfaction. This effect has also spilled over to more traditional areas and sectors in the B2B context where customers are increasingly demanding the same experience, no matter the type of business or the channel. This change in expectations requires that supply chains become increasingly and rapidly customer-centric. Besides, the customer experience has become bidirectional, with customers expecting easy product return, and customer interests are extending beyond quality and price to encompass also the social and environmental impact of their consumption.

All these changes require that leaders transform the managerial mindset from integrating forecasting, planning and execution activities layer by layer to deploying technology to enable seamless and real-time data management, i.e., convert the chain into digital supply networks.

## Digital supply network and its processes

Broadly, the DSN is an integrated set of digitally enabled supply chain capabilities powered by an interconnected flow of information ("The Rise of the Digital Supply Network: Indus-

FIGURE 1

### Traditional supply chain

The process and flow of supply chain management.

#### Supply Chain Management (SCM) Process



#### Supply Chain Management (SCM) Flow

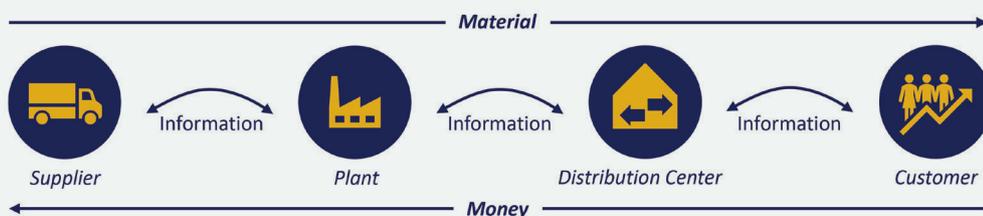
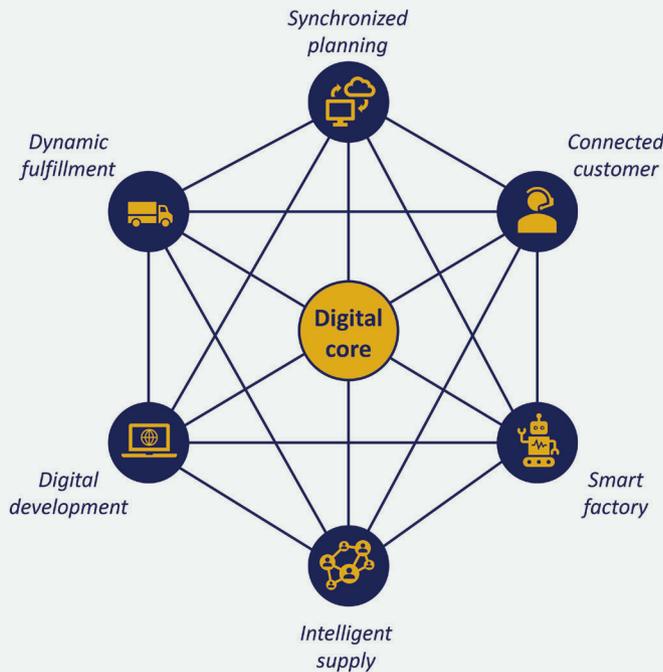


FIGURE 2

## DSN and its processes

A display of the fundamental capabilities of digital supply networks (adapted from “The Rise of the Digital Supply Network: Industry 4.0 Enables the Digital Transformation of Supply Chains,” 2016).



try 4.0 Enables the Digital Transformation of Supply Chains, Adam Mussomeli, Doug Gish and Stephen Laaper, Deloitte Insights 2016), as shown in Figure 2. The traditional sequence of develop, plan, source, make, deliver, return and support is transformed into one of interconnected information flows and advanced capabilities. This change enables the DSN to become smart, always-on, always-connected, real-time and dynamically adaptive.

At the center of the DSN is a digital core, which leverages inputs from its multiple nodes to self-strengthen. As a result, it accelerates production, distribution and delivery to customers by providing real-time information to make data-driven decisions, anticipate risks and offer better end-to-end visibility. The digital core uses analytics to methodically turn internal and external data into predictions, insights and alternatives for directing or even automating operational actions and decisions. A mature DSN must have six fundamental capabilities that the digital core integrates and simultaneously orchestrates: Dynamic fulfillment, synchronized planning, connected customer, smart factory, intelligent supply and digital product development.

Here’s a peek at each of the fundamental DSN capabilities.

**Digital development:** This capability leverages technology to conceptualize, design and launch products into production, ensuring cross-functional collaboration through the product life cycle and improving design efficiency to develop high-quality products that satisfy individual customer needs. It reduces

R&D expenses and product maintenance costs and increases manufacturing flexibility. Reduction in manual intervention results in fewer errors, delays and inefficiencies, which helps the company respond quickly to changing customer requirements and increased personalization. Automation also promotes faster product launches while minimizing the environmental impact during development through

process efficiency and digital technology.

**Synchronized planning:** This capability aligns strategic business objectives with financial goals and operational plans across various functions within the business. This disposition helps to effectively anticipate customer demand and optimize inventory in the overall DSN. It utilizes historical and real-time data and customer perceptions to predict baseline customer demand. It helps in optimizing portfolios with the product, service and packaging roadmaps and in designing optimal supply networks, balancing the desired responsiveness levels with the lowest transportation, warehousing and manufacturing costs. It is capable of sensing exceptions across the supply chain and ensures on-time fulfillment of demand.

**Intelligent supply:** This capability helps companies to more effectively collaborate with strategic partners and improve the customer and supplier experiences by adopting advanced electronic platforms for requisitions and invoices. It also helps anticipate supply risks to optimize end-to-end operations proactively. Technologies such as machine learning and artificial intelligence (AI) can support the prediction of cost fluctuations and selection of sourcing strategies to optimize costs.

**Smart factory:** This capability uses a calculated balance of human and machine intelligence to drive improvements in business performance and worker safety based on production and demand data. Sensor data, image recognition and collaborative robots can optimize overall production efficiency and

The image shows the cover of a publication titled '2020 and BEYOND THE FUTURE OF ISE'. At the top is a stylized white logo consisting of a circle with a horizontal line passing through it. Below the logo, the text '2020 and BEYOND' is written in a large, bold, white font, with 'THE FUTURE OF ISE' in a smaller font underneath. The main title '2020 and Beyond: Supply chains' is prominently displayed in a large, bold, white font. Below the title, there is a short introductory text: 'In this issue, our series “2020 and Beyond: The Future of ISE” looks at growing trends in supply chains. To read previous issues in the series, visit <https://link.iise.org/iise2020>.' The background is a dark blue gradient.

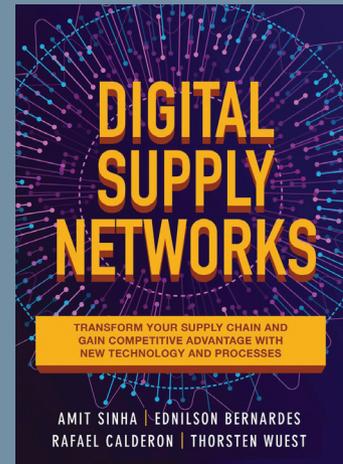
## Making sense of information overload on transformation journey

The article is excerpted from the upcoming book *Digital Supply Networks: Transform Your Supply Chain and Gain Competitive Advantage with New Technology and Processes* (McGraw-Hill, available July 2020), which examines the impact new technology is having on supply chain management processes and practices. Drawing from real world-experience and problem-driven academic research, the authors provide an in-depth account of the move to digitally connected supply networks. They discuss the limitations of traditional supply chains and the underlying capabilities and potential of digitally-enabled supply flows.

The chapters are filled with expert insights and real-life use cases, consisting of an essential guide to developing digital supply networks for maximum competitive advantage. The book discusses the critical enabling technologies, provides guidance on their deployment, and illustrates their application in building the DSN capabilities.

The book is written in an accessible and non-technical format that will cater to a broad audience, including executives, managers, leaders, academics and students involved in or interested in developing a solid foundation on this topic. Professionals contemplating the journey or already in its midst will benefit from the insights.

The content applies to all business sectors and industries, with a particular focus on supply chain and manufacturing.



provide safe and ergonomic work environments for employees. Smart factories also take a proactive approach to maintenance to optimize planned downtime and predict potential outages. It helps in making informed trade-off decisions to identify opportunities to improve performance standards and ensure compliance in real time, improving product quality.

**Dynamic fulfillment:** This interconnected, cross-enterprise capability delivers the right product to the right customer at the right time, enhancing the overall customer experience. It utilizes technologies such as IoT and robotics to provide real-time visibility and flexibility across the supply chain, promoting cross-functional collaboration and improving responsiveness. The risk of product recalls due to counterfeit practices is reduced as well, protecting brand reputation. It also helps enable intelligent customer order management, improving customer experience and reducing obsolescence costs. This capability can reduce startup costs and increase risk resilience as well.

**Connected customer:** This capability allows companies to move from a traditional transaction-based relationship to seamless customer engagement throughout the entire customer life-cycle. This setup results in better anticipation of customer needs, enriching the customer experience. It also enables faster resolution of issues and customer consumption pattern identification. Technologies such as advanced analytics, machine learning and artificial intelligence support the effective segmentation of customers to provide relevant promotions. Utilizing dynamic fulfillment capabilities, companies can track and monitor physical products and ensure the timely delivery of high-quality products to customers.

The data and information from all six digital supply network capabilities converge into the digital core to be stored, distributed and analyzed. The DSN model, enabled by new and dis-

ruptive technologies, creates the following outcomes that differentiate DSN from the traditional, linear supply chain:

- End-to-end transparency, allowing visibility across the entire supply network.
- High levels of agility, driving flexible and proactive response of supply network levers.
- Connected environment, enhancing cross-functional collaboration across all partners.
- Resource optimization, promoting a cohesive environment for humans and machines.
- Holistic decision making, improving network efficiency, lower cost and higher revenue.

### Digital supply network key enabling technologies

To achieve the potential benefits of a DSN model, leaders must implement a powerful suite of technologies to enable new digital capabilities that address supply chain challenges. However, it behooves us to alert organizations and leaders that the transformation of traditional supply chains into DSNs is not about merely deploying new technologies. It is about leveraging them to design entirely new supply network operating models based on a shared digital foundation. These technologies include blockchain, robotics, sensors, additive manufacturing, autonomous vehicles, virtual reality, machine learning and AI, big data and analytics, etc. Underlying a common digital foundation core are data, analytics and AI-centered capabilities.

Data and data exchange are a crucial factor of success for traditional supply chains. The more hierarchical structure of these conventional supply chains influence both the way data are generated, exchanged and analyzed, as well as the potential value-

add of data for all stakeholders. In contrast, for DSNs, stakeholders are working together at a more agile and collaborative level. This architecture creates tremendous opportunities when it comes to capitalizing on the actual value of data at the network level for all areas of business.

However, the dynamics and complexity of such DSNs pose some distinct challenges when it comes to data, data exchange and being able to derive insights from large amounts of shared information within the network. The digital nature, connectivity and the ability to exchange and analyze data in real time electronically define DSNs.

As such, a critical enabling factor of a DSN is the ability to collect, process and communicate/store data from a diverse set of sources. These data sources include but are not limited to information technology (IT) systems (such as ERP, CRM); sensors (temperature, GPS); operational technology (OT) systems (machine tools); publicly available data (social media, reviews); as well as financial (transaction data, stock market). These data sources can be located anywhere – within the organization, within the DSN or externally, adding an extra layer of complexity to the system.

AI is about providing cognitive intelligence to processes and machines. This procedure can use machine learning (ML), which relies on pattern recognition algorithms to interpret and translate data into real-time insights, thereby simplifying tactical planning and automating the decision-making process. For instance, leaders can adopt machine learning to improve sourcing insights and procure-to-pay process efficiency by studying historical and real-time data.

We can cluster machine learning algorithms into three general approaches to develop predictions using statistical models (“Machine Learning in Manufacturing: Advantages, Challenges and Applications,” *Production & Manufacturing Research*, Thorsten Wuest, Daniel Weimer, Christopher Irgens and Klaus-Dieter Thoben, 2016): Supervised learning, where an expert labels the dataset of known outcomes; unsupervised learning, where there are no or few known outcomes; and reinforcement learning, which does not rely on an expert-labeled dataset or pattern-anomaly recognition, and feedback instead drives dynamic improvement.

An AI system combines and utilizes machine learning and other types of data analytics methods to achieve data intelligence capabilities. The overall objective of AI and ML is to discover patterns in the data and provide a prediction of the future behavior of a system or process based on identified, often intricate patterns. These predictions can target a variety of different issues, including detecting problems or (process) inefficiencies, market trends, customer behaviors, environmental impacts, financial indicators or quality issues. AI and ML are the foundation for many new concepts and DSN capabilities, such as predictive maintenance and dynamic fulfillment, to name a few. The ability to analyze large data sets, identify (hidden) patterns

and derive meaningful, actionable insights from the predictions are a powerful tool that has applications in virtually every aspect of business within a DSN.

## Challenging journey toward a successful DSN model

In the last decades, digitization started taking advanced forms and providing tremendous value and competitiveness to pioneering companies. For instance, storage, materials handling and packaging in distribution centers have made incredible inroads toward automation. However, most supply chains still operate in staged and separate sequential silos. Besides, organizations have typically fragmented supply chain and operations systems and data across functions and units, which hinders the aggregation of data, delays the generation of intelligence and limits organizations in leveraging the real capacity of analytics and AI. The way forward is redesigning how the supply chain and its processes work and transforming the way it gathers and uses data, senses and reacts to customer information, makes decisions and executes operating tasks.

Organizations and leaders not only need to redesign the operating model of traditional supply chains, but also navigate the myriad solutions and technologies emerging in the marketplace. Understanding the classes of technologies that can support the journey and making sense of their underlying potential to support strategic capabilities are a daunting task on its own. Besides, they need to overcome the challenges of legacy and siloed systems and proactively define and develop the skills and capabilities of the workforce necessary for the transformation process and the future DSN.

The journey is not for the faint of heart, but the rewards are worth it; in reality the transformation is not optional. Rivals will outcompete organizations that do not successfully embark on the journey toward developing DSN. ♦

*Amit Sinha is a specialist leader at Deloitte Consulting, U.S. He is an expert in digital transformation, technology and supply chain transformation for the value generation to the enterprises and society.*

*Ednilson Bernardes, Ph.D., is an award-winning researcher and professor of supply chain management. He has led process innovation and digitization initiatives in the aerospace industry and other large organizations.*

*Rafael Calderon is a principal at Deloitte Consulting, U.S. He has 20 years of industry and consulting experience helping global companies drive operations performance through large scale growth and efficiency initiatives.*

*Thorsten Wuest, Ph.D., is an assistant professor at West Virginia University and J. Wayne and Kathy Richards Faculty Fellow in Engineering at the Benjamin M. Statler College of Engineering and Mineral Resources. He is an IISE member.*