How to Build a Digital Supply Chain: Focus On Capabilities

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The topic of digital supply chains has been in the forefront of the minds of executives across all industry sectors. Digital transformation (AKA: digitalization) is the process of developing digitized data, integrating communications, and automating processes to improve performance in many dimensions. For example, some companies have achieved unprecedented levels of visibility and efficiency. Multiple factors had converged over the past few years to enable the building of digital supply chains, including availability of big data, analytics, artificial intelligence (AI), robotics, and the Internet of Things (IoT). These advances are being combined with developments in hardware (e.g., servomechanisms) and software (e.g., machine learning) to rapidly make automation of processes (both manual and transactional) cheaper and more reliable. Yet many companies, and supply chain managers in particular, have been in a 'wait and see' mode when it comes to digitalization. The Covid-19 crisis has changed that, shining a light on the need for supply chain visibility and responsiveness, and creating an even greater push toward supply chain digital transformation.

Over the past three years we have studied the state-of-the-art of digital supply chain transformation. We wanted to understand the keys that lead to successful transformation and obstacles that impede development. We conducted in-depth interviews with senior leaders of over a dozen large companies, all household names, across a range of industry sectors. We then conducted deep case studies of two companies, one a major airline, the other a leading consumer electronics firm. Through multiple site visits, data gathering efforts, and analysis, we observed and participated in the process of digitalization at these firms.

Our conversations and work with supply chain executives at numerous firms have produced insights into the factors that are separating leading firms from laggards. First, more successful transformation efforts build upon a set of common underlying features that define what a digital supply chain looks like – and how it differs from a traditional supply chain. Second, more advanced firms' visions of digital maturity build upon core attributes that convey a natural progression of capabilities. Third, and perhaps most important, leaders are strategically targeting well-defined capability development efforts that provide differential competitive advantage. In contrast, lagging supply chain organizations seem to mostly be stuck in incremental change efforts designed only to address pain points and cost reduction opportunities. Most of these projects are limited "capital for labor" substitutions, with little linkage to more strategic goals. Many supply chain leaders make the mistake of focusing on technological solutions rather than building capabilities. Companies need to focus less on the technologies themselves and more on the underlying capabilities they enable when they are combined with complementary changes in organizational structures and human capital.

WHAT MAKES A SUPPLY CHAIN "DIGITAL"?

Three trends are fueling digital supply chain transformations: The first is an abundance of data, generated by traditional transaction-based systems (e.g. POS, RFID, ERP) as well as sources of less well-structured data (e.g. video surveillance and other monitoring systems, online clickstreams, social media postings, blog/wiki entries, forum discussions, etc.). Supply chains are increasingly instrumented – sensors, tags, trackers, and other smart devices are collecting real time data on a wide variety of processes. Second, enormous advances in data storage, computing power, and intelligent algorithms are enabling faster and more comprehensive processing of data. Computing architectures such as in-memory processing, cluster computing, and cloud computing have enabled the storage, retrieval, analysis, sharing, and distribution of data faster, cheaper, and with greater accuracy. Rapidly improving algorithms, including machine learning, are automating transactions, diagnosing problems, uncovering insights, and optimizing decisions as they enable efficient processing of wider scopes of data and broader sets of objectives. Third, improvements in sensors and servomechanisms, and in the programming of these devices, are enabling greater levels of process automation. Robots have moved beyond the manufacturing shop floor to find applications in transportation, warehousing, and physical services. These advances are collectively enabling digital technologies to augment or replace humans' senses, brains, muscles, and means of communication.

We asked dozens of supply chain managers to define "digital supply chain," and received dozens of different answers, ranging from "one integrated system with one single data base" to "digitizing all transactions" to "making all things digital" to "visibility into demand and supply." After pondering these responses and reviewing related literature, a clear set of defining characteristics emerged. Digitalization is certainly about automation, as we noted above; but when applied to supply chain management, digitalization also enables greater integration of processes and greater illumination of real-time insights into events and transactions, into cause-and-effect relationships, and into the value of decision alternatives. Accordingly, a digital supply chain can be defined as follows:

A digital supply chain develops and applies technologies to automate, integrate, and illuminate all processes including data capture, communications, analyses, decision-making, transactions, and transformations.

Automation and augmentation enable digital supply chains to achieve massive improvements in accuracy, speed, quality, and cost. In addition to this foundational understanding of the nature of supply chain digitalization, our conversations and case studies pointed up four core attributes that undergird transformation of conventional supply chains into digital ones.

1. Digital Supply Chains are "Digitized"

It all begins with data. The primary virtue of a digital supply chain is that it provides current, accurate, complete, and relevant data. While sensors and transaction management systems provide supply chain managers with enormous amounts of data today, typically only a small fraction of it satisfies all four of these criteria. Accordingly, developing the ability to sense, capture, standardize, and clean data that has strategic value and to rapidly process it into useful forms (information) is a huge first step toward digital maturity.

2. Digital Supply Chains are Integrated

Supply chain managers increasingly complain of being awash in data but lacking in information they can actually use. Information is created when data are combined, filtered, structured, and reported in useful ways. Managers often use the term, "visibility" to convey this capability. Automated transactions, translations, and communications provide visibility that supports more real-time, integrated planning and decision making. This integration is the hallmark of a digital supply chain. Dashboards, alert systems, control towers make broader sets of current information more actionable and enable managers to have information upon which they can act.

3. Digital Supply Chains are Intelligent

Pervasive availability of rich, real-time information enables greater analysis and insight into demand, supply, and operational processes. Information and data plus algorithmic analytics capabilities enables both robotic and human decision makers to diagnose situations and events, predict possible outcomes, assess scenarios and risks, and prescribe and execute courses of action.

4. Digital Supply Chains are Adaptive

The ultimate core attribute of a digital supply chain is adaptability, the ability to act upon derived insights quickly and efficiently. This attribute is the one least commonly associated with "digital," but it likely has the greatest impact on performance. Data, information, and insights are of little value if operations are so fixed and immobile that managers are unable to pursue time-sensitive opportunities. Predictions from analysis are most accurate in the short term. Thus, to realize the full value of a digital supply chain, it must be able to quickly respond and act upon the intelligence it creates. Technologies such as robotics, additive manufacturing, and on-demand resources (e.g., transportation, production, etc.) offer effective ways to increase adaptability in a supply chain.

Enabling Technologies

The popular press offers numerous examples of technology applications in supply chain processes, including artificial intelligence (AI), robotics, and predictive analytics. Figure 1 groups these and other enabling technologies based on their primary purpose and capabilities.

Supply chain leaders indicated that keeping up with technology was a key challenge, highlighting the importance of working with excellent partners to evaluate, select, and develop solutions. Equally important, the leaders suggested the need for a larger view of integration across technologies, due to the limitations of existing systems. For example, they said:

- "ERP is too transactional – it doesn't give you the tools to do advanced planning and integration with external partners needed."
- "As a technology company, we tend to be susceptible to the promise of technology without fully appreciating the cost/difficulty of the supporting changes required."
- "Our supply chain personal still wonder if a given technology is sufficiently mature. We have questions about who should pay for the technology, how processes should be changed, etc."

Figure 1: Technologies Enabling the Digital Supply Chain

Type of Technology	Capabilities	Examples
Analytics/decision technologies 	Provide computing power, intelligence, and data management, making higher-quality decisions faster.	•Advanced planning systems (APS) •Supply chain network design •Management and execution systems (TMS) (WMS) (MES) (YMS) (OMS) •Forecasting and demand management •Advanced analytics and machine learning
Processing technologies 	Automate transactions and material processing to provide 24/7 resource availability, faster processing, improved consistency, and cost.	•Programs, software robots •Computer-aided design and machining, 3D printing •Industrial robots, flexible manufacturing systems (FMS) •Drones and autonomous vehicles •Automated storage and retrieval systems (AS/RS)
Communications technologies 	Create greater accuracy, currency, connectivity and visibility, speeding flows of richer forms of information.	•Sensors, scanners and radio frequency identification (RFID) •The Internet: Wi-Fi, narrow band, cellular, microwave, radio, etc. •Satellites, fiber optics, etc. •Electronic data interchange (EDI), global data synch network (GSDN)
Integrative/platform technologies 	Combine data management, communications, visibility, traceability, decision support, and processing capabilities.	•Cloud computing and services/Blockchain •Mobile applications and wearables •Augmented and virtual reality, global positioning systems (GPS) •Enterprise resource planning (ERP) , Product life cycle management (PLM), Relationship management (CRM) (SRM) (CPFR)

Technology adoption and enablement is clearly a huge topic in itself, and an important differentiator in the maturity of digital supply chains. Our conversations with supply chain executives strongly suggest that leaders should focus on linking the core capabilities of technologies with business level strategies, rather than simply focusing on solutions to problems.

In a world filled with hyperbole and up-to-the-minute stories of technological advancements, the reality is that most firms, even leading ones, are not that far along with digital transformation. All the leaders we spoke with stated, somewhat apologetically, that they believed they were behind the industry curve in digital processes, and certainly a long way from reaching "maturity."

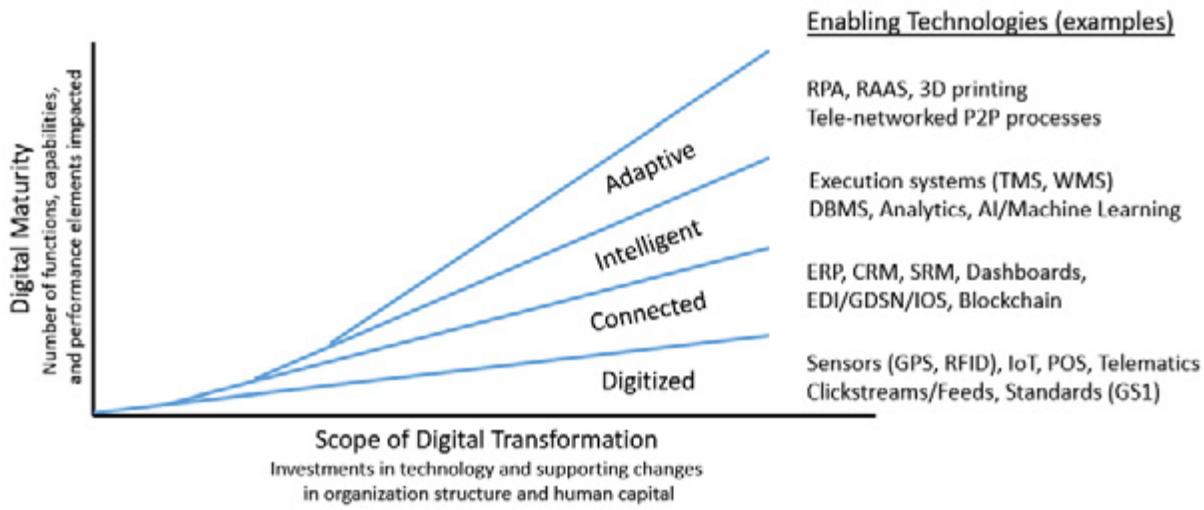
GROWING DIGITAL MATURITY

The four foundational attributes of a digital supply chain can guide a beginning analysis of existing and needed capabilities. For many firms who are starting the digitization journey, an important question is, which of the attributes presents the biggest obstacle or opportunity?

1. Getting the right data in the right form at the right time
2. Communicating data as useful information to the right stakeholders
3. Deriving actionable insights from the information
4. Adjusting operations quickly enough to capitalize on the insights

It is important to recognize the precedence relationships among these core elements. As illustrated in Figure 2 below, each successive element builds on the foundation created by the prior step. A distinctive attribute of maturity that emerged from our conversations with leaders is an enlarged scope of transformation that includes integrated, systems-oriented, objectives and projects. Developing technology solutions in parochial supply chain functions is relatively easy, compared to larger, more integrative initiatives. Executives leading digital transformation strategies must balance opportunities to solve problems in specific function and process areas against the opportunities offered by more integrative, strategic programs of change.

Figure 2: Digital Maturity Model

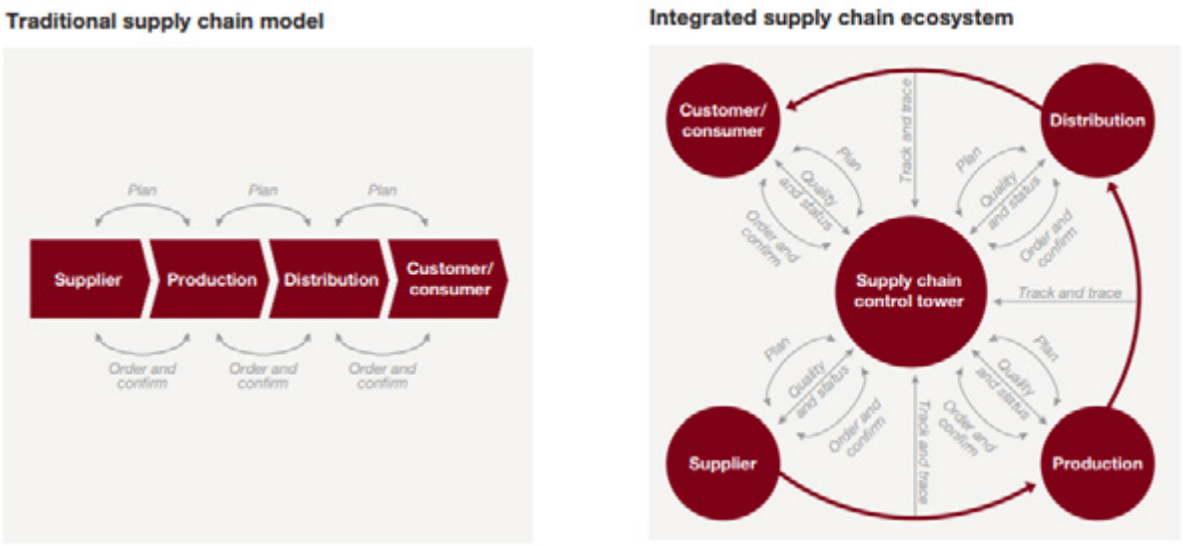


Key enablers of the journey toward digital supply chain maturity include structural changes in both organization and human capital. When asked about the key obstacles to change, all interviewees agreed that organizational issues create the greatest challenges. Leaders stated that limitations in culture, talent, and organizational structure form greater impediments to transformation than technological limitations do. Innovative organizational structures and talented human resources are foundational to digital supply chain transformation.

An initial challenge for many firms is determining where to place transformation leadership within the organizational structure, especially structures that lack CSCO or CTO offices which offer natural homes for responsibility. Longer term issues surround the best way to organize supply chain functions in order to capitalize on the integration and adaptability that digitalization offers. In a traditional supply chain model, there are linear linkages from suppliers through production and distribution, until we reach the final customer. Information flows linearly back and forth, and each entity depends on the other supply chain partners for truthful information sharing.

Digital transformation, on the other hand, allows a supply chain to be centrally controlled via a supply chain control tower as shown in Figure 3. A supply chain control tower is a central hub that can capture complete visibility, providing better organization and processing. It enables a complete view from suppliers, production, distribution, to final customers. Rather than hoping that supply chain partners will share information, a digital supply chain is set up to automatically share information as it is created. There is nearly complete visibility; the control tower enables the company to 'see' what is happening at every juncture. With complete information and visibility, the company has better ability to foresee upcoming events such as delivery delays or financial implications. It can spot where problems are, such as delays in inbound shipment of supplies for a factory, or warehouse delays. It also has the ability to conduct scenario planning with 'what if' analysis to understand the implications of various decision options, and to conduct risk analysis regarding various suppliers and scenarios. This means that a digital supply chains offers an elevated ability to manage the supply chain that goes beyond the ability to 'see' but also 'foresee,' and ultimately make better decisions.

Figure 3: Digitization Brings Visibility and Control



Today, data analysts are playing increasingly important roles in the development and use of analytics that make diagnoses and predictions; tomorrow's systems will require a more general set of skills, including business domain knowledge, to properly interpret and apply prescriptions made by increasingly intelligent software agents.

DIGITAL SUPPLY CHAIN CAPABILITIES

Constraints imposed by organizational structures and limits of human capital pose important challenges to supply chain digital transformation. However, when we asked supply chain managers about impediments to progress, the majority named the lack of a guiding roadmap as the largest obstacle. A good roadmap guides selection of projects for a transformation portfolio and is shaped by the specific strategies and competences of the firm. Each firm's roadmap will be unique, as it matches its unique circumstances.

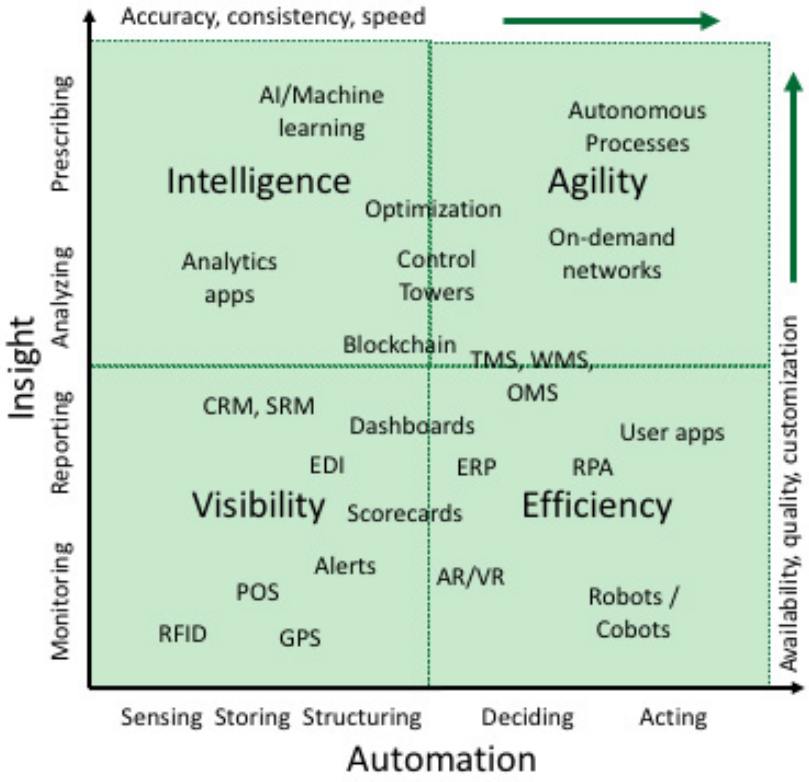
It is difficult to formulate a guiding vision when so many technology options are available, and when operating conditions are so dynamic. Many managers spoke of their frustration in trying to build a five-year plan when they were unsure of how markets might change, what technologies might emerge or become obsolete, and what new competitors might appear even over the next twelve months! In the midst of all this change, a capabilities perspective offers a clearer and more stable approach for planning. While the value of certain digital technological solutions might change, the importance of selected capabilities is likely to be longer lasting. Supply chain leaders should target specific capabilities that follow the maturity model in a way that addresses immediate problems, but also capitalizes on opportunities to differentiate their supply chains in supporting the firm's business model(s).

Managers can think about capabilities at different levels – we present three hierarchical levels of capability here. Two fundamental digitally enabled functionalities define "Level 1" capabilities: automation and insight. First, digital technologies can be used to substitute automated processes, performed by devices, computers, or robots, for all kinds of processes performed by humans. These processes might involve sensing, where devices replace human senses (sight, taste, touch, smell, hearing), structuring and storing information and making decisions, where computers replace human brains, and executing physical tasks, where robots replace human muscles. Substituting software and hardware (capital) for labor can lower costs, but automation also importantly speeds-up processing and transitions, improves consistency and accuracy of task execution, and increases resource availability (services are "always on").

Second, digital technologies accelerate and enrich insight into supply chain processes and decisions. Monitoring and reporting technologies increase timely availability of information, connecting stakeholders. Algorithms and smart analytics "cognify" processes, that is, they develop and apply knowledge through analysis, optimization, and learning. In these ways, smart technologies improve the quality of solutions developed and decisions made. In addition, by enabling more granular insight into demand and supply processes (beyond the cognitive load of humans), digital technologies create the potential for more customized responses to market opportunities in both demand and supply.

Figure 4 juxtaposes automation and insight as two core dimensions of digital technology enablement, positioning examples of digital supply chain technologies that enable these two broad types of process transformations. The automation axis represents increasing automation of processes in overall sense-analyze-respond cycles. Many technologies automate actions and decisions, including data capture, computations, transactions, physical transformations and movements, and more. The insight axis represents increase depth of insight developed as data is converted to information to knowledge to plans. Data capture, communication, and analytics technologies derive, develop and infuse insights and intelligence into processes by sharing and analyzing information and by prescribing solutions and actions.

Figure 4: Digital Capabilities Matrix



Combined functional applications of automation and insight can create four "Level 2" supply chain management capabilities; each positioned in a quadrant of the digital capabilities matrix. Strategic leaders can combine automation and insight in ways that create tremendous opportunities for supply chain transformation, building capabilities that create competitive advantages. In its most essential form, digital transformation is about developing automation and insight to radically advance visibility, intelligence, efficiency, and agility.

Visibility means having "valuable" information you need at the time you need it. Information value comes from data that are current, accurate, complete and usefully formatted. As we discussed at earlier, visibility requires digitization and connectivity for the processes and stakeholders involved. As an important step toward digital transformation maturity, leaders must identify the types of visibility that are crucial to competition. Typically, this means visibility that reduces or eliminates the most damaging uncertainties in the supply chain, and/or visibility that offers the greatest potential for improvement and competitive advantage. Leading firms develop visibility using these criteria, rather than simply exploiting types of visibility that are readily available. Almost by definition, developing visibility requires working with upstream and downstream partners to develop data standards, along with technologies for data capture and connectivity.

Efficiency is broadly defined here; it spans many types of improvements in the uses of resources, including time as a resource. Supply chain managers often think immediately of automation as a means to efficiency. Capital-for-labor substitution truly is an important source of efficiency and productivity gains—it has been so since the Industrial Revolution. New technological capabilities go far beyond the basic benefits of greater efficiency, however.
Efficiency improvements from automation now include better process speed, quality, service availability,

and improved user interactions. In manufacturing, emerging examples illustrate the super-productivity of robots and humans working side-by-side; such arrangements are more productive than either robots or humans working alone. In services, automation is improving interactions between service providers and customers, as well as between supply chain partners. Leaders will do well to ask for more than efficiency gains alone from investments in automation. Visibility is a foundation for efficiency. Improved visibility from automated data capture and processing, and from greater transparency and connectivity foster opportunities for automation of both physical and informational transactions, making them more efficient.

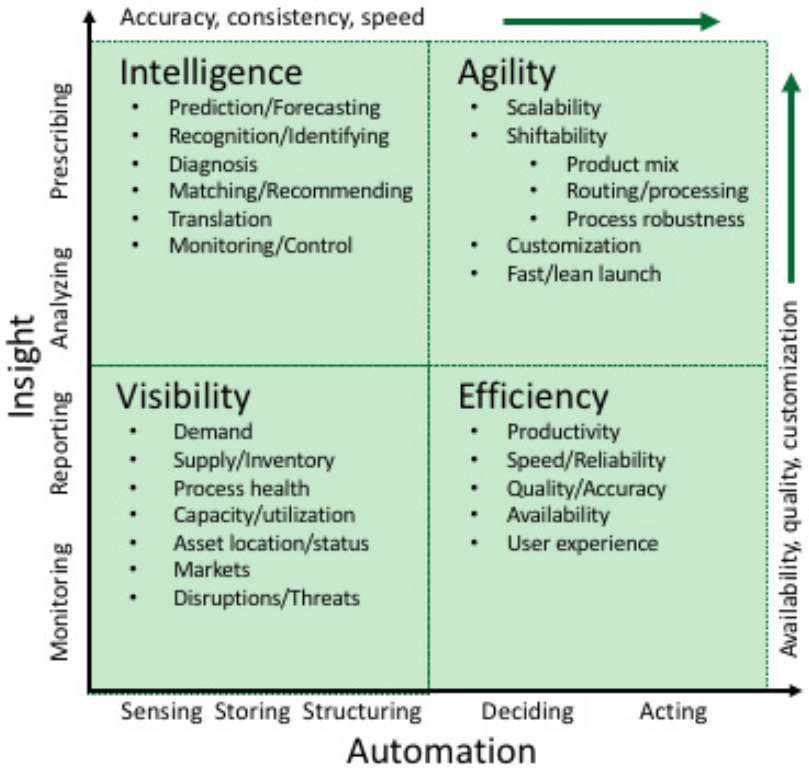
Intelligence adds knowledge to visibility in ways that provide insights needed to drive effective actions. Visibility lays the foundation for next-level insights enabled by applying intelligent algorithms to visible data. Smart programs using machine learning and other types of artificial intelligence can provide deeper understanding of trends, anomalies and even causes of process effects. These technologies tend to be the most useful when applied to repeated processes that produce massive amounts of data such as sales, clickstreams, asset monitoring and other transactions. Levels of intelligence include visualization, advanced analytics, prediction and prescription. For example, visibility in a digital supply chain enables a firm to rapidly identify operational bottlenecks and risks. Intelligence enables it to understand root causes and to prescribe effective remedies.

Agility is the ability for supply chains to rapidly and economically respond to problems and opportunities. One manager we spoke with described agility as "Seamless end-to-end demand-supply matching and adjustments." Agility combines a number of different types of flexibility in processes, resources, and capacities. It is the ultimate outcome of combining efficiency and intelligence. Visibility immediately points up problems or opportunities. Intelligence prescribes an effective response. Efficient automation executes the response quickly and economically. Monikers frequently used to describe this capability include "on-demand," "uberized," "mass-customized" and "responsive." Essentially, agility means breaking constraints and unfixing capacities in the supply chain, moving to variable cost structures, and building flexibilities that enable rapid scalability, supply-demand matching, seamless transitions and changeovers, increased operating range, optimal re-routing, and dynamic sourcing.

An important starting point in developing a digital transformation roadmap involves identifying the specific pain points and opportunities that the plan should address. Again, supply chain managers should define these issues in terms of needed capabilities, rather than quickly jumping to technological solutions. Ideally SCM managers should prioritize capability development efforts that provide maximal differentiation in the marketplaces that they serve.

Figure 5 provides an inventory of "Level 3" capabilities, ordered within the higher-level capabilities established by the capabilities matrix. Digitization initiatives can be targeted to develop specific capabilities within the larger capability quadrants.

Figure 5: Level 3 Supply Chain Capabilities



The popular press contains many examples of technology applications aimed at improving specific capabilities. Many applications are in the visibility quadrant. For example, restaurant chains like IPC/Subway are investing in data standards, scanning technologies, and data management systems to beef up track-and-trace visibility for produce and protein supply items. They reckon that such traceability will payback millions of dollars in recall efficiencies and brand benefits should quality issues arise. Other firms have prioritized visibility into asset locations and status (e.g., trucks and storage equipment), process monitoring, and demand sensing (e.g., point-of-sale systems). Following a number of high-impact disruption events, some firms have invested in monitoring services that provide early warnings of weather changes, political events, or labor actions that could disrupt flows in their global supply chains. It is important for managers to consider what types of visibility are most important to the success of their business. Which visibility type addresses the most impactful uncertainty in the supply chain?

Analytics applications can provide insights of different kinds, from relatively simple monitoring and control capabilities to more intensive prediction models. Lower level applications build on visibility platforms to monitor and control inventory levels and process settings, for example. One firm we spoke with is using machine learning algorithms to recognize and diagnose anomalies in thousands of purchase orders and invoices, a level of analysis that would be impossible to perform manually. The highest levels of

insight emerge from applications of predictive and prescriptive analytics. For example, Lennox, a leading manufacturer of HVAC equipment, has the monumental task of managing repair parts inventories for tens of thousands of items across hundreds of service locations. Recently, the company partnered with ToolsGroup SO99+ to develop an intelligent program that forecasts SKU-location level demands in 200+ "micro-climates" that they system identify as sharing common seasonal weather patterns.

Managers should design automation investments to improve efficiencies in the most strategically important areas. Usually automation is targeted based on potential cost reductions (often labor costs), but it is important to also consider potential top-line benefits from automation. For example, automation can provide greater resource availability and customer satisfaction. Cemex, one of world's largest suppliers of cement, ready-mix concrete, and aggregate products wanted to extract its business from intense price competition. The firm worked with IBM to consolidate fragmented databases and automate processes, designing an end-to-end user experience defined by eight connected mobile apps that cover all order-to-cash transactions, as well as pre and post sales support. The apps allow construction foremen to schedule and track deliveries, establish and change delivery locations and times, manage quotations, pricing, invoices and payments, disputes and customer service, all from a smart phone. In addition to seeing dramatically improved customer satisfaction and revenue growth, Cemex has cut back office staff for AR/AP and call centers by more than 35%.

Dimensions of agility represent the most strategic capabilities of all. Developers of transformation roadmaps need to prioritize the types of agility that are most important in coping with the most salient dynamics in their business environment. For a manufacturer in a highly seasonal marketplace, scalability may be most important. For an innovator dealing with rapidly changing technologies, product launch flexibility may be most important. For competitors in fashion who are subject to changing consumer tastes, product mix flexibility may also be important. For example, Nike is embarking on a massive overhaul of its supply chain to build speed and adaptability into its operations. For new products in the pipeline, managers are focusing the demand chain on e-commerce, tighter distribution through retail partners (including Amazon), and developing systems to manage numerous delivery channels. These moves improve the visibility of demand signals while giving partners options for optimizing customer service. On the supply side, Nike's is using automation and 3-D printing to keep labor costs down and make products quickly.

At the highest levels of maturity, firms apply digital technologies to automate, integrate, and provide insight into processes so that they can predict and adapt to changes, including shifts in demand and supply, local and global disruptions, environmental and regulatory changes, and competitors' actions.

DIGITAL TRANSFORMATION: TWO CASE STUDIES

As part of our research, we had the opportunity to work with two supply chain organizations in the throes of digital transformation. Both organizations were chasing somewhat incremental improvements to supply chain processes, based on priorities established by pain points and cost reduction opportunities. These two case studies illustrate how transformation efforts can be made more strategic when they are guided by a capabilities-oriented approach.

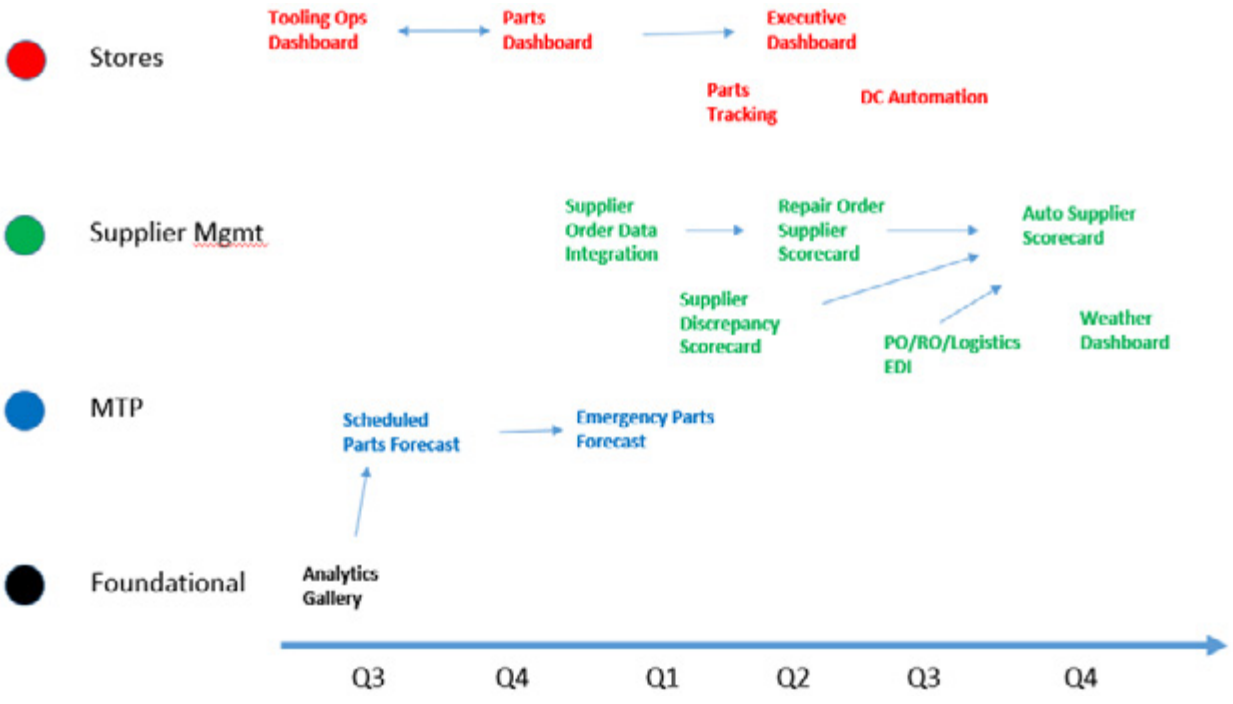
Case 1: Technology Maintenance Organization (TMO) Group

The first case study involves the technology maintenance organization (TMO) for a major airline. The organization is tasked with maintaining a globally positioned, multi-billion-dollar stock of aircraft. The aircraft are maintained and repaired at numerous airports as well as at major hubs located around the world. Supply chain operations include the management of a complex system of parts, tools, procedures, and labor needed to support both scheduled and unscheduled (emergency) maintenance and repair activities. The TMO leadership stated that their overarching goal was to minimize delays by always having the right parts, tools and resources at the right place at the right time. The organization has been pursuing digital transformation over a period of years with that stated goal in mind.

Our analysis revealed that each of the major functional groups within the TMO was pursuing multiple technology development projects, with about 15 on-going projects in total. However, the groups' efforts were mostly independent, with little coordination or integration. As we reviewed each of the projects with the leadership team, it became clear that almost all of them were aimed at improving visibility to the TMO's various demands, processes, and inventories. While the team envisioned improvements in resource availability and service lead-times resulting from these technology developments, they struggled to articulate how the improvements would fit into a larger strategy of better supporting the overall mission of the firm. It was clear that a unifying, overarching strategy was missing.

An important first step was to get functional leaders from each area to meet regularly to identify and explain the goals and planned deliverables of each of the projects in their areas, to think about the capabilities that these projects would provide, if successful, and to consider how the projects could be integrated in ways to build toward a more intelligent, efficient, and agile supply chain. Figure 6 illustrates the timing and precedence relationships among the projects. When presented with this information, the team could see that the projects were very functionally focused, with few integrative connections. The only cross-functional, foundational effort underway was the "analytics gallery" project, which was aimed at giving managers the ability to custom-build scorecards and dashboards to schedule and share their workflows.

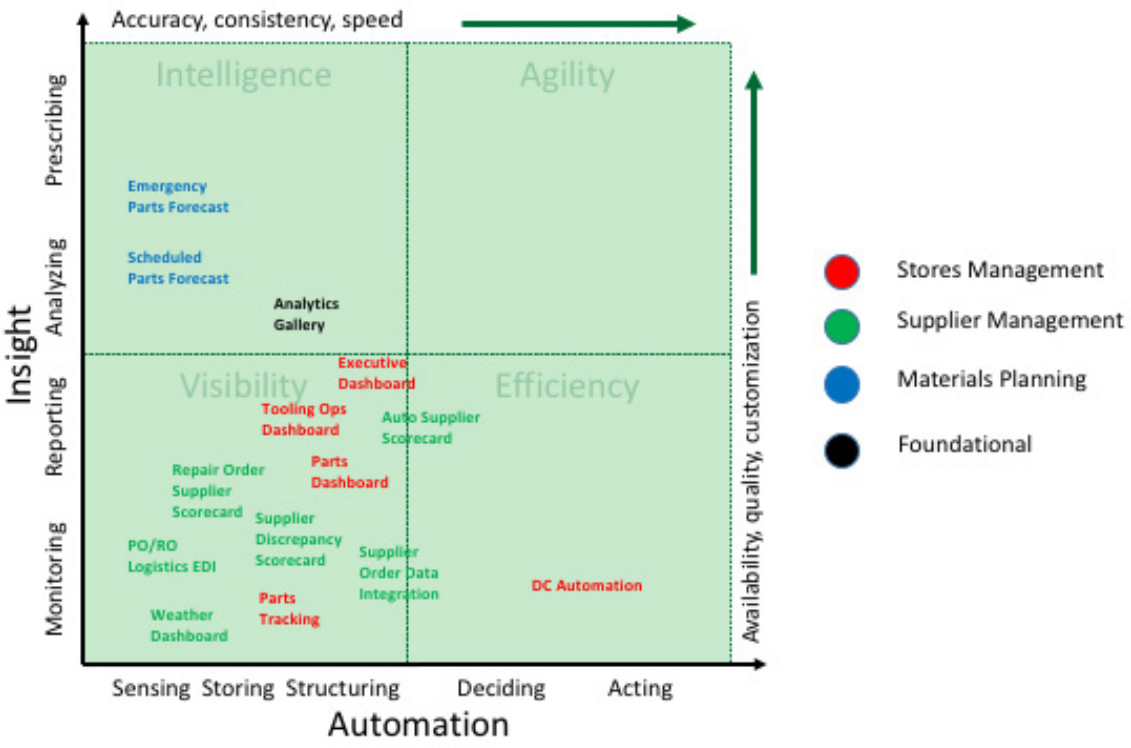
Figure 6: TOG Digital Transformation Projects



We then mapped each of the projects on to our capabilities matrix as shown in Figure 7. By viewing the projects in this way, the team could see the totality of the results of their individual efforts. Mostly using manual processes, the projects were essentially applying data management and analytics tools to improve visibility and to develop some early levels of intelligence, mostly in areas of parts demand forecasting. The team had not previously recognized that their emergent focus was primarily limited to the development of various types of visibility. This recognition opened a discussion of what additional efforts and new projects were needed to advance the organizations' investments and technology initiatives "up and to the right" on the matrix, ultimately building more agile capabilities.

The other key insight that emerged from this mapping process was an identified need to develop more platform-oriented initiatives that could serve as foundations for other capabilities developments. While the "analytics gallery" project provided a self-service tool for managers to build reports, all the other projects were functionally oriented and quite focused in their scopes of objectives. The TMO team recognized the need to build more cross-functional applications that served to integrate data and planning processes on an enterprise-wide basis. Overall, team leaders dedicated themselves toward developing tighter links to the overarching vision (right part, right place, right time, efficiently), rather than allowing each functional area to independently pursue only its local pain points.

Figure 7: TMO Digital Transformation Projects



Case 2: Consumer Electronics Business (CEB)

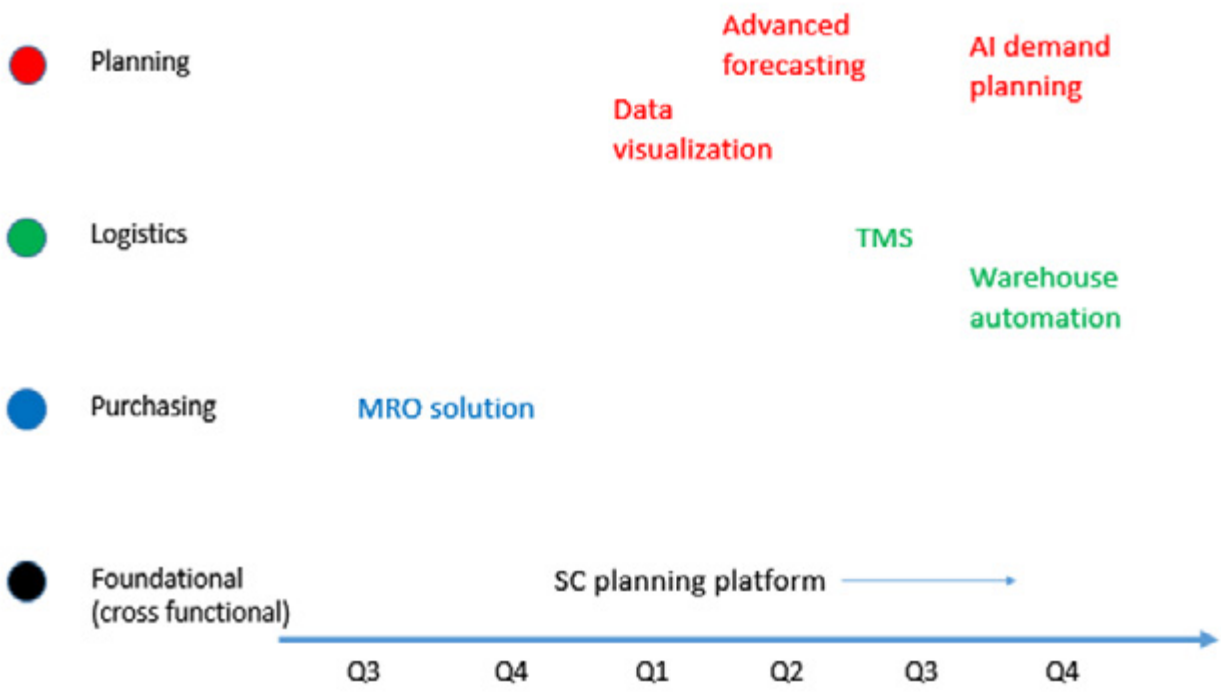
Our second case study offers a contrast to the technology maintenance organization, both in terms of operating environement and transformation scope. The study involved the supply chain leadership team for a major consumer electronics business (CEB). While the company is well known for its cutting-edge electronics products, over the past ten years the business had outsourced much of its manufacturing needs. As a result, the supply chain team was finding it difficult to plan and control operations needed to meet highly volatile demands for its products.

As with the first case study, we conducted multiple in-person meetings with the team. The company had also been undergoing digitial transformation for a few years but was not sure how they compared with other firms and which directions to take. The company's leadership shared that their primary goal for transformation efforts was to be able to answer the question: "If a customer asked for 10,000 additional units, how long would it take us to fill that demand?" We suggested to the leadership team that at the heart of this question is the capability of supply chain agility, in partcular, scalability.

While this suggests that the group was pursuing a capabilities-oriented approach to digital transformation, their actual focus was more on evaluating and adopting specific technological "solutions", with murky linkages to the overall goal. Like the airline TMO, the CEB leadership team was not aware that what they really needed was to develop the capability of agility. Rather, they were pursuing adoption of a number of technological solutions to give the company increased visibility to support some planning processes they thought they needed, without understanding the capabilities each solution offered, and how the solutions linked together.

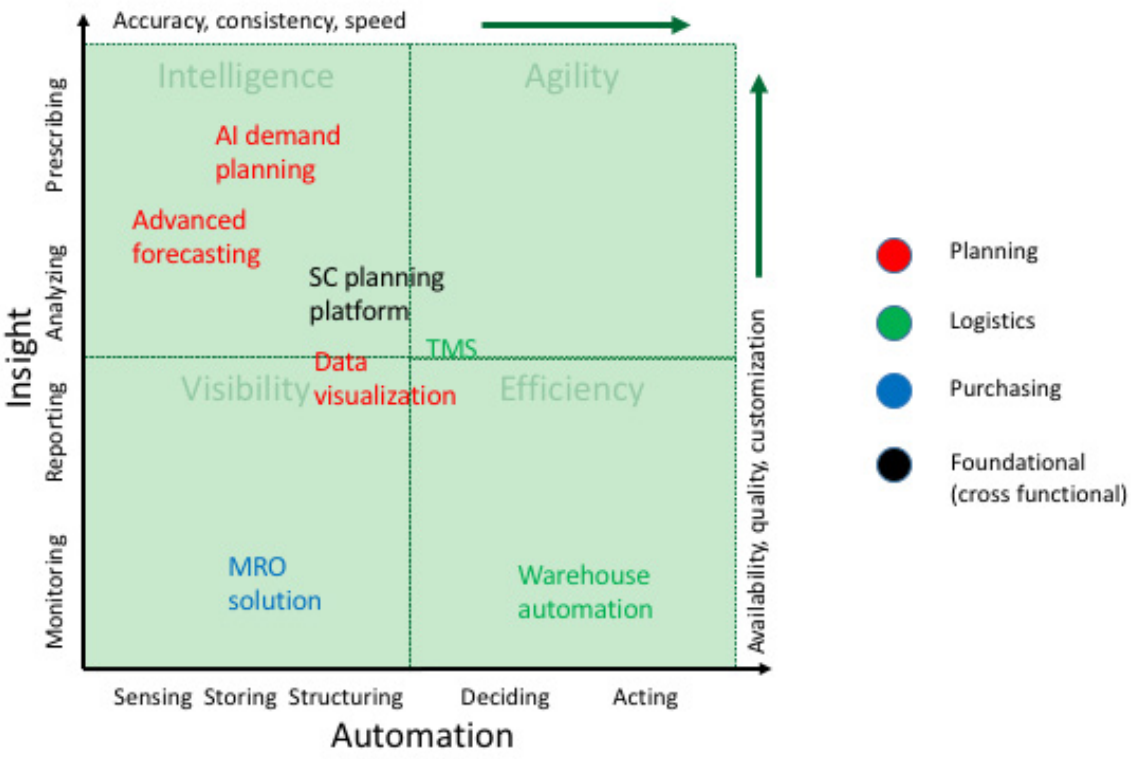
For us, the first step was to look at the different technological solutions pursued by the company and to identify the capabilities each offered. As the illlustration in in Figure 8 suggests, the team had selected the different solutions for different functions, essentially following a 'projects perspective.' As companies pursue technologies to address different functional needs, it is common to fall into this behavioral pattern. In this case, solutions were acquired over time in the functional areas of Planning, Logistics, and Purchasing, without cosideration of how they might be combined to create unified capabilities.

Figure 8: CBE Digital Transformation Projects



When the company's "solutions" are mapped on to our capabilities matrix as illustrated in Figure 9, the fundamental capabilities of each became clear. While many of the chosen solutions were best-in-class, each enabled specific capabilities limited to lower and leftward quadrants; none started to address capabilities within the agility quadrant. Ultimately, the solutions the team was pursuing were not sufficient to help the company achieve their primary goals of agility and scalability.

Figure 9: CBE Digital Transformation Projects



The ultimate lesson for the team was to plan more specifically how their current visibility oriented investments could be used to advance toward agility. Originally, they primarily thought of visibility as the needed capability to answer the question "how long would it take to fill an unexpected, additional demand." This understanding was based on the assumption that additional demands would be satisfied using existing processes. We encouraged them to think about how digitalization could help them build more robust and flexible processes, so that the answer to the driving question would be shaped by two capabilities: 1) visibility to guage inventory and capacity levels in real-time, and 2) agility to change sources and capacities as needed to meet the new demand. More broadly, the leadership team recognized the need to develop a 'capabilities perspective' rather than only the project based perspective that had dominated their thinking.

As was the case with the TMO Group, the key insight that emerged from the mapping process was the need to develop a more strategic plan and time table. Like the TMO, the company decided to move toward more platform-oriented initiatives that would serve as a coordination for all the other functions. In this case, the company decided to push forth with a supply chain planning platform that would enable the creation of a digital supply chain control tower. They were committed to having end-to-end supply chain visibility. To support this broad reaching effort, the company decided to pursue wide organizational structural changes concomitent with the technological changes. This included increasing the breadth of skills, cross-functionality and understanding of all employees. The company recognized that they would

gain the greatest benefits from the technology when they are combined with complementary changes in organizational structure and human capital. They also decided to make a concerted effort toward a more coordinated and transparent organizational effort. Lastly, once they understood the idea of capabilities, they decided to consider taking it further, deciding to choose initiatives that differentiate their capabilities in ways that provide a competitive advantage

MOVING FORWARD WITH SUPPLY CHAIN DIGITIALIZATION

We embarked on this research project to gather insights into the unique factors that are giving some companies the lead in supply chain digitalization. The interviews and case studies revealed interesting insights into the process of successful digital transformation. Across all of the companies we contacted, managers expressed a keen interest in knowing how they were doing; even as well-known, major companies, they were mostly unsure as to how their digital transformation progress compared to the competition. They were also uncertain as to the next steps they should follow. Most were acquiring popular technological solutions to address key pain points and sometimes guiding directives, yet they lacked effective ways to guage progress toward higher order goals.

Most managers, especially those in the two case study organizations, found the idea of a "capabilities perspective" to be novel and useful. Presenting the capabilities matrix with its dimensions, and showing how each company's efforts mapped on to matrix was an eye opening moment. A set of key lessons learned emerged from our conversations and experiences with these companies.

- First, successful transformation requires a company's leadership team to develop a shared understanding of what a digital supply chain looks like. Everyone in the organization needs to understand how digital supply chains are different from traditional supply chains. Digitalization involves transforming processes to build insights, not just automating them for efficiency. A common vision and understanding allows everyone to move in the same direction as they proceed through the digitalization journey.
- Second, the leadership team should develop a maturity model, identifying the critical stages of digitalization for their organization. Firms need to build on each stage of the maturity model, which conveys a natural progression companies need to follow. Companies cannot jump from stage to stages but need to build their digitalization skills as they move through the stages in various functional and regional divisions of the overall supply chain.
- Third, companies need to understand the difference between acquiring "solutions" and developing "capabilities." This is perhaps most important lesson of all, and one that was underscored in our case studies. Though both of the organizations we studied had clearly stated operational goals, neither had taken the step of thinking through the digitally-enabled capabilities they would need to reach their goals. The Supply Chain Capabilities Matrix can be useful in illustrating capabilities offered by technology solutions. Companies need to focus less on the technologies themselves and more on the underlying capabilities these technologies enable.
- Fourth, it is important to consider foundational initiatives and complementary technologies in ways that lead to a time-phased roadmap for digital transformation. Most organizations are good at creating Gantt charts that show the schedule for project, but many fall short in fully thinking through the ways that some technology development initiatives are supportive or even necessary prerequisites for the success of others. This is especially true when transformation efforts are spread across functional organizations that operate somewhat independently.

The findings of our study reveal that while digital transformation is an imperative for just about all companies, many leaders lack a clear vision of how to move forward. To implement the capabilities-based model we propose here, transformation managers should consider following some change management best practices.

Form a Guiding Coalition with Someone in Charge: Many supply chain organizations struggle to implement sweeping, integrative digital transformations because authority and responsibility are spread across differenct functions. Not all firms have CSCOs. Even if supply chain management leadership is centralized, questions such as "is digitalization a SC issue or an IT issue?" still arise. Before developing a capabilities oriented roadmap, leaders should come together to create a coalition, often know as a steering committee, that includes representative stakeholders from IT, supply management, operations, logistics, engineering, marketing, and sales. Funding for projects will almost necessarily require budget inputs from all functional areas, as all areas will be affected by integrative changes.

Focus on Customers and Competitors: Went contemplating the capabilities that should be prioritized in the supply chain, it is tempting to think only about the biggest headaches the organization currently faces. For capabilities to truly have market value, however, they need to be developed in ways that clearly differentiate the firm in the minds of customers and from the capabilities of competitors. Select capabilities that create competitive advantage and support the business objectives, rather than ones that only solve current problems.

Plan for Organization and Talent Changes, Not Just Technology: Most veteran managers understand that people, processes, and technology have to be developed together. However, this maxim is particularly important for digital transformation. Often, the limiting factor is not the technological solution itself; it is instead the inability of the organizational structure to capitalize on new capabilities, or the lack of human resources with the necessary talents to effectively implement and utilize the technology.

Frequently Update the Plan: Rapidly evolving technologies and operating environments threaten to make transformation roadmaps obsolete almost as soon as they are constructed. A capabilities-oriented plan is likely to be more stable than a solution-oriented plan is. However, it will still be important to frequently (e.g., quarterly) revisit and update plans based on the progress of on-going projects, newly emerging technologies, and changes in the marketplace.

Supply chain leaders have little choice but to embrace both the opportunities and risks of digital transformation. Success will depend on their ability to understand in a deep way the capabilities their processes need to offer, given the ways that the firm competes and differentiates itself in the marketplace. This requirement calls on supply chain executives to develop strategic views of their supply chain functions, and to think beyond solving problems. Successful transformations will develop new value-creating processes.

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