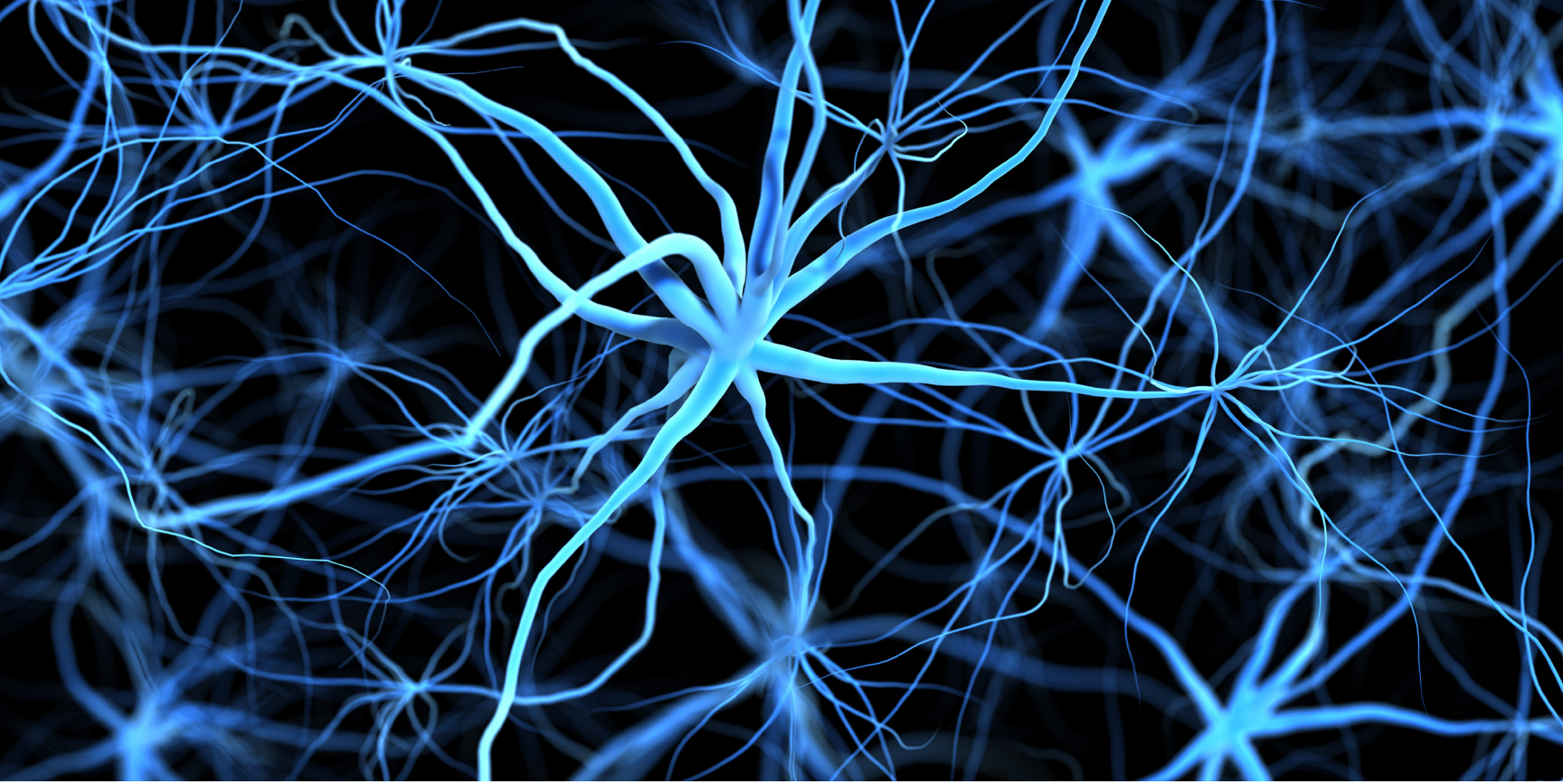


Welcome to the cognitive supply chain

Digital operations – reimagined

IBM Institute for Business Value

How IBM can help

The Cognitive Internet of Things (CIoT) is creating the potential to enable new markets and grow new revenue streams. We see this rapidly evolving market pushing at the boundaries of what is possible today. Clients need strategies to harness this potential for real-time actionable insight, apply predictive analytics and enable their digital transformation. IBM Digital Operations for IoT and supply chain management offers integrated services, software and infrastructure solutions. Our portfolio includes Connected Solutions, Building & Asset Optimization and Next Generation Supply Chain. Connect with us to navigate this dynamic, rapidly changing landscape in the artificial intelligence (AI) and cognitive computing era. Visit **ibm.com**/services/us/business-consulting/digital-operations-internetofthings.

Unparalleled operational excellence

Supply chain executives across all industries have been developing digital strategies over the past several years. They are aggressively addressing integrated technologies, including the Internet of Things (IoT) on mobile, collaborative and cloud-based platforms. These executives are applying predictive analytics even more rapidly to all supply chain processes, including asset, inventory, fleet and energy management. They are further automating digital manufacturing, customer service and distribution with robotics and drones. And now, in this cognitive era, these digital operations are being enhanced even more – with artificial intelligence (AI). When combined with advanced automation, thinking and learning, supply chains can be trained to augment and enhance human decision making and bring about a new level of operational excellence.

The future has arrived

The futuristic renderings of science fiction movies and literature have become reality, and robotic likenesses are now automating and instrumenting learning supply chains. The next wave of technology – artificial intelligence (AI) – is already making sense of the deluge of operational data streaming in from a plethora of devices and cloud applications. This technology is also applying advanced mathematics to create products, processes and systems that are able to adapt and learn.

We predicted these developments in 2010, when we envisioned what we called the smarter supply chain of the future. We foretold that smarter supply chains would need to be:

"Instrumented. Information that was previously created by people will increasingly be machine-generated – flowing out of sensors, RFID tags, meters, actuators, GPS and more. Inventory will count itself. Containers will detect their contents. Pallets will report in if they end up in the wrong place.

Interconnected. The entire supply chain will be connected – not just customers, suppliers and IT systems in general, but also parts, products and other smart objects used to monitor the supply chain. Extensive connectivity will enable worldwide networks of supply chains to plan and make decisions together.

Intelligent. These supply chain decisions will also be much smarter. Advanced analytics and modeling will help decision makers evaluate alternatives against an incredibly complex and dynamic set of risks and constraints. And smarter systems will even make decisions automatically – increasing responsiveness and limiting the need for human intervention."[1]

Less than a decade later, our predictions are becoming reality.

More than half of outperforming supply chain executives surveyed said their top investments in the next three years will be cognitive or cloud

86% of outperforming supply chain executives surveyed said cognitive computing will transform their demand planning and forecasting capabilities

92% of outperforming manufacturing executives said AI and cognitive computing will enhance performance in production planning

Adaptive robotics act on Internet of Things (IoT) device information and a multitude of structured and unstructured data to learn and make autonomous decisions. Natural language processing (NLP) tools can understand human speech and react to what they are being told. Predictive analytics are being applied to demand responsiveness, inventory and network optimization, preventative maintenance and digital manufacturing. Search and pattern recognition algorithms – which are no longer just predictive, but hierarchical – analyze real-time data, helping supply chains to react to machine-generated, augmented intelligence, while providing instant visibility and transparency.

Bob Stoffel, former Senior Vice President, Engineering, Strategy and Supply Chain at UPS, said, "When we talk about supply chain visibility, it does not simply mean visibility into your own supply chain. It means visibility among partners, which enables collaborative decision making closer to the customer. This is both a science (managing the technology) and an art (using the information and metrics for competitive advantage)."[2]

AI is becoming essential to innovative supply chain transformation. Forty-six percent of supply chain executives anticipate that AI/cognitive computing and cloud applications will be their greatest areas of investment in digital operations over the next three years (see Figure 1).

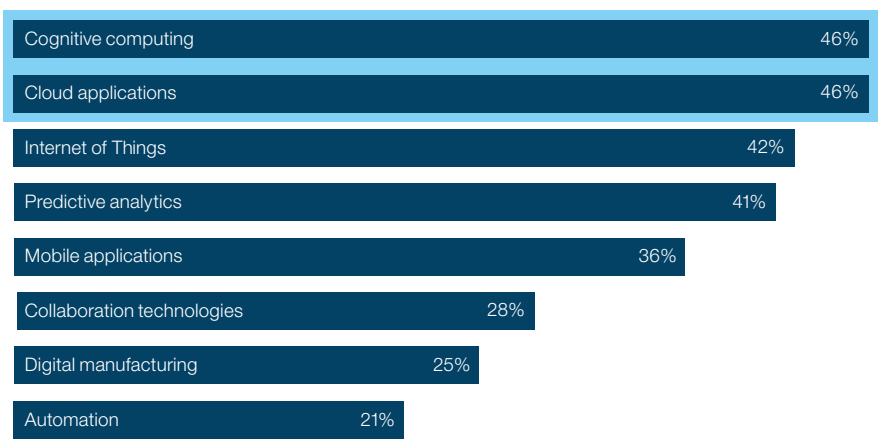
To better understand the impact of AI and cognitive computing solutions on supply chain and operations, we surveyed senior operational executives across a wide range of industries and geographies. We asked more than 1,600 Chief Operating Officers (COOs), Chief Supply Chain Officers (CSCOs) and executives of product development, procurement and manufacturing about their current views on AI and cognitive computing, their priorities and the value that they expect to derive. (For more information, see "Study approach and methodology," page 19.)

Our research shows that COOs and CSCOs are aggressively reinventing business models, strategies and technological capabilities. They are resolute on assisting the CEO in defining agile business models and working with the CMO to support the go-to-market strategy, while backing investments and explorations into new ways of optimizing their supply chain operations.

Pioneering firms are applying these AI and cognitive technologies to their products and their daily operations. Some are living the future; others have just begun the journey.

Figure 1

Executives predict their greatest digital operations investments over the next three years



Source: IBM Institute for Business Value

Supply chain is a natural fit for AI

In our global research data, we identified a group of more than 700 outperformers (12 percent of the total sample) with stronger financial performance than their peers. These companies, across many industries, report annual revenue growth and profit increases of more than 5 percent over the past three years. We ranked public sector organizations based on effectiveness and efficiency.

Eighty-eight percent of the highest-performing organizations surveyed report that AI is inevitable in their industry. Among those polled, fully 95 percent of the highest-performing organizations see AI as central to their innovation success.

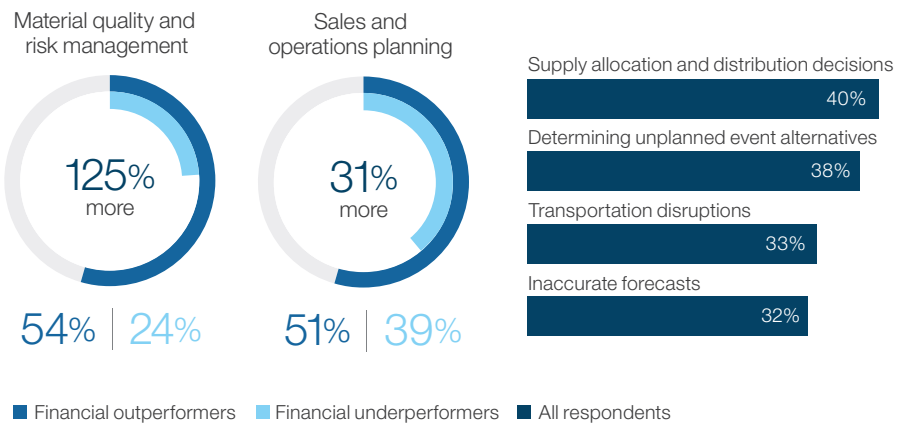
COOs and CSCOs are looking to AI and cognitive computing to resolve many of their end-to-end supply chain process challenges, and financial outperformers are investing in AI more (see Figure 2). The most common applications of these technologies are directed at material quality, preventative maintenance, and risk management from supply to production to customer provision.

Machine learning is becoming mainstream in the operational technology portfolio. Baseline forecasts for new products are instrumental in determining new product introductions and go-to-market plans. When applied to demand signals, AI can determine changing demand behaviors and optimize inventory levels and replenishment plans to feed the continuous loop of product lifecycle management.

Sales and operations planning is the ultimate collaborative decision-making process. Companies can apply AI technologies to sales and operations planning and other massive supply chain data pools to manage demand volatility, supply constraints, production scheduling and dynamic distribution. AI can augment human interaction by allocating resources, assigning people and scheduling processes.

Figure 2

How companies are using cognitive computing and AI to resolve supply chain challenges



Source: IBM Institute for Business Value

Machine learning capabilities apply algorithms to massive operational data feeds to discover insights to track and predict supply chain disruptions, providing new levels of visibility into day-to-day operations. These capabilities can also recommend alternative actions for unplanned events and transportation disruptions. Weather data integrated with operational data can predict potential problems and alert transportation and logistics service personnel with recommended actions.

And in manufacturing, collaborative robots equipped with AI software can "see" their environment and move in a safe manner around the humans working alongside them in production.

In our research, we asked a set of distinct questions about the priorities, plans and purpose of employing AI capabilities in three distinct and complex supply chain areas:

- Product development
- Procurement
- Manufacturing.

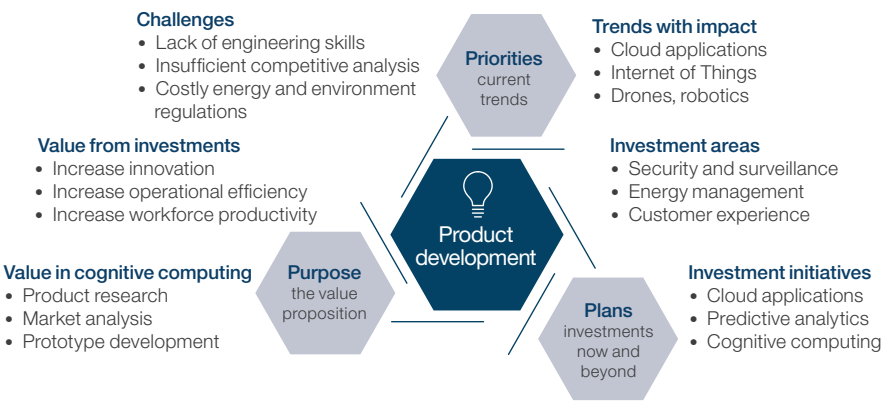
The priorities represent the business and competitive challenges, as well as the current trends, that will affect companies' operations. The plans are the investments in technology, processes and people that organizations are making and plan to make over the next three years. And the purpose represents those initiatives, with emphasis on intelligence, that executives are prioritizing to aim for the highest return on their investments.

The future unfolds: Innovative product development

Across industries, executives face many challenges in getting the right product to the right customer at the right time. And to bring innovative products to market, they are challenged with combining capabilities from new technologies such as IoT, drones and robotics with enterprise cloud applications. Many research and product development executives are experimenting with cognitive computing capabilities embedded into their products and their operations. Cognitive computing is supporting product research and market analysis, as well as product development and production (see Figure 3).

Figure 3

Product development priorities, plans and purpose



Source: IBM Institute for Business Value

Using image-processing models to identify elusive problems

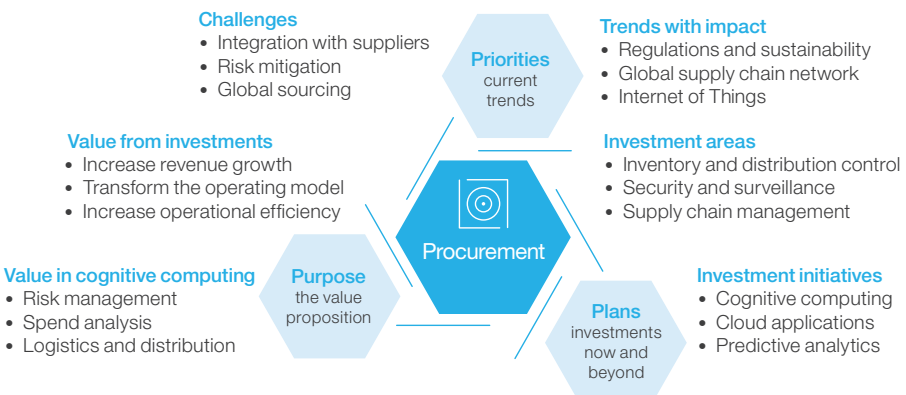
Experts know that it takes trained eyes to spot when something's not right at the top of a cell phone tower. Hundreds of feet up, it could be a frayed cable, a spot of corrosion on a support or any one of a long list of potential warning signs. A drone maker in the Netherlands saw the convergence of IoT and cognitive computing as an opportunity to develop a new tower inspection capability. The company's new products use image-processing models that are trained to identify anomalies within high-resolution images captured by drone-mounted cameras. These intelligent drones are helping to keep risky tower accidents to a minimum, reducing costs and increasing service reliability.[3]

The future unfolds: Intelligent procurement

Chief Procurement Officers (CPOs) are concerned with maintaining the health of their global supply chain networks, which face added pressures of regulations and security risks, while transforming their operating models for revenue growth (see Figure 4). But their organizations have a great deal of data buried in contracts and transactional systems and externally, among regulators, that can be applied for intensified procurement insights. Using cognitive computing capabilities to parse through unstructured data, such as news feeds and social networks, can augment learning for supply risk scoring and supplier performance.

Figure 4

Procurement priorities, plans and purpose



Source: IBM Institute for Business Value

CPOs report that their top three technology investment initiatives over the next three years will be cognitive computing, cloud and predictive data analytics. During that same period, more than a third of CPOs will focus these investments on supply chain management transformation. They are seeking to bring secure, real-time transactions to source-to-settle processes, while advancing predictive analytics in global inventory optimization. We found that for many, especially in the manufacturing and distribution industries, gaining visibility, insight and understanding in buy and supply functions is mission critical.

The anticipated returns on these investments will be to increase operational efficiency, grow revenue and transform the operating model. Cognitive technologies can bring the comprehensive visibility needed to gain true insight into supply chain disruptions and risks. With this new level of understanding, procurement professionals can predict outlier events and put plans in place before these events occur. In fact, 40 percent of CPOs expect that cognitive computing will add value with risk mitigation, spend analysis and global logistics and distribution.

Cognitive procurement capabilities bring supply chain optimization

It's hard to overstate the importance of an efficient, low-cost supply chain for contract manufacturing companies. An electronics contract manufacturing service provider in the United States knew that to drive more data-driven decision making among procurement specialists, it needed to be smarter about all of its suppliers – not just the biggest. That meant addressing the reality that procurement staff simply lacked the time to dig out and analyze volume and pricing details for thousands of smaller supplier relationships – as important as they are.

So the company developed an AI procurement solution that brought all supplier relationships under the same microscope. The solution pulls together diverse unstructured data from within and outside the company and visualizes it in a way that helps specialists make quick and accurate decisions. By bringing the same granularity of insight to all supplier relationships, the company opened a new frontier for supply chain optimization.[4]

Filling the gaps in public transportation with self-driving buses that talk to passengers

In an effort to expand public transport to areas that are not served by conventional public transportation options, a vehicle manufacturer developed a new on-demand capability that chats with passengers about destinations, recommendations and more. Using collaborative design, the manufacturer developed a small, efficient vehicle that drives itself and communicates with passengers. To bring the vehicle "to life," the company integrated more than thirty onboard sensors. This IoT solution understands and responds to a flood of data from the sensors feeding these buses while in operation. Passengers request service using a phone app and speak directly to the vehicle. Their input is channeled into navigation decisions and conversational interactions, as the vehicle discusses best routing options, provides recommendations on local points of interest, and learns each passenger's preferences.[5]

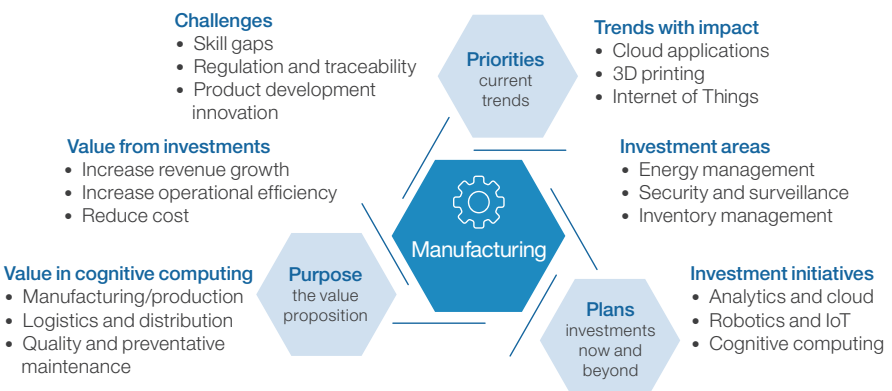
The future unfolds: Learning and automated manufacturing

Manufacturing executives are working hand-in-hand with their product development colleagues to bring innovative products to market and support their companies' growth and profitability agendas. They are rapidly implementing the foundational technologies of IoT and cloud, and advancing into the automation technologies of adaptive robotics. And now, the industry is engaged in its next automation breakthrough – using AI to make production decisions in real time (see Figure 5).

In automotive production, for example, when a sensor discovers a defect, it feeds data to the cloud production application, which immediately requests that the defective part be pulled from the line and a replacement ordered.

Figure 5

Manufacturing priorities, plans and purpose



Source: IBM Institute for Business Value

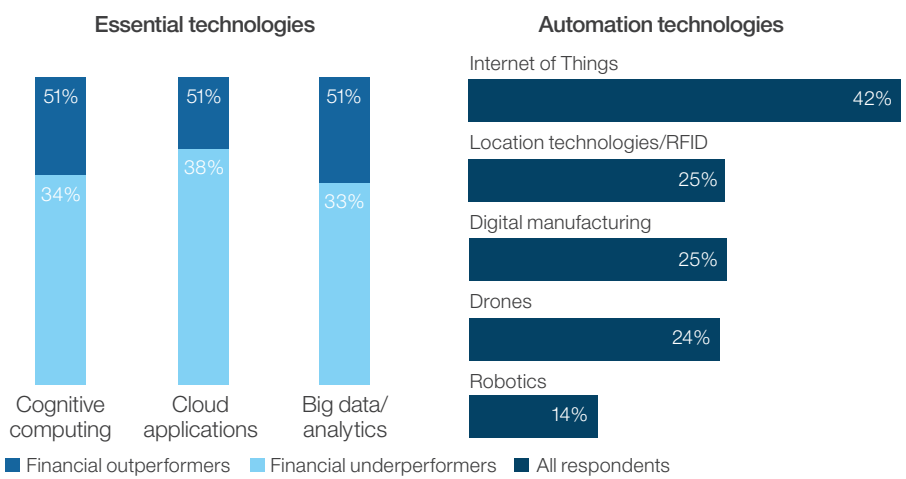
AI and cognitive computing underpin future automation

The AI and cognitive computing journey progresses as automation technologies are receiving more attention, and more investment, from COOs and CSCOs. Automation includes both software bots, such as application programming interfaces (APIs) and algorithms, and mechanical robots. A new augmentation is adaptive robots – cognitive IoT-interconnected and intelligent machines – which are being used to personalize products and services, improve operations, reduce costs and elevate efficiency.

Coupled with the greater IoT ecosystem, adaptive robots can learn from other connected devices to cyclically improve their actions. To innovate their supply chains, financial outperformers are investing more in the essential technologies while continuing to invest in automation technologies (see Figure 6).

Figure 6

Which technologies companies are deploying; financial outperformers are at the adoption forefront



Source: IBM Institute for Business Value

Cognitive services support hands-free productivity

A German manufacturer of advanced earphones saw an opportunity to evolve its consumer product in a way that would improve worker productivity. The company incorporated services from a cognitive IoT platform into a new offering that enables workers to use simple verbal commands to summon complex information and receive targeted communications to help them complete immediate tasks. The technology supports hands-free communications, helping workers to remain productive while getting the technical and learning information they need.[6]

Cognitive computing adds significant value across digital operations

AI and cognitive computing are enhancing, in varying degrees, all areas of supply chain management. Topping the list of current applications is the use of automation for event and emergency response, asset management and global network design – all for proactive and predictive responsiveness. But let's look to the near future. Operational executives have big plans to completely transform their capabilities in demand, risk and security management, as well as in the customer experience, verifying a customer-centric perspective on future undertakings (see Figure 7).

Figure 7

The effects that cognitive computing may have on operations, according to respondents

Source: IBM Institute for Business Value

The various case studies in this report demonstrate the potential value and innovation of applying AI to further automate devices and operating processes. In a nutshell, pioneering leaders are building more cerebral operations, with the goals of

- Increasing revenue and entering new markets
- Increasing operational efficiency and agility
- Increasing innovation to achieve competitive advantage.

In the past decades, we have advanced supply chain processes from “sense and respond” to “predict and act.” Now we have supply chain capabilities that can feel, perceive, react and learn. AI is next-generation supply chain management that enables unparalleled operational excellence.

The cognitive supply chain journey

The road to successful cognitive, or learning, supply chain management may seem long and daunting at first thought. The journey, like most, must be strategically planned and executed with a roadmap to value. After working with and observing successful digital reinventions of organizations in every industry, across the globe, we have developed a course of action.

Imagine the future

We learned from the financial outperformers and C-suite operations executives in this study how important it is to integrate the business strategy with the operating model. But many companies lack a clear strategic vision and plan for digital operations. Our analysis shows that the most financially robust companies are following a transformation roadmap.

The roadmap should include a program of many innovations and launches. Envisioning workshops use design thinking to understand customers, clients and colleagues through brainstorming sessions and visualizing operating use cases. Align these initiatives with the target operating model and ecosystem strategy.

Example supply chain use cases that incorporate AI might include:

- Available to promise: Use real-time customer demand and environmental data to better align the committed and actual date with the requested date.
- Put away strategy: Combine connected material handling machine data, spatial and location data, as well as existing product data to optimize the existing rules and policy for inventory storage.
- Production route determination: Augment advanced process controls (APCs) with machine data, energy consumption, customer segment, demand and sales campaign data to sequence and schedule production processes and routes, as well as respond quickly to changes when necessary.
- Safety stock planning: Optimize safety stock levels at a more granular level with the use of additional dependent system information from both the vendor and customer.

From the use cases, create prototypes using agile development techniques. Augment capabilities and continue to build and deploy IoT products and operation control devices supported by enterprise cloud applications for real-time visibility. Articulate the impact and business case. Don't forget to develop scorecards to monitor the prototype into implementation.

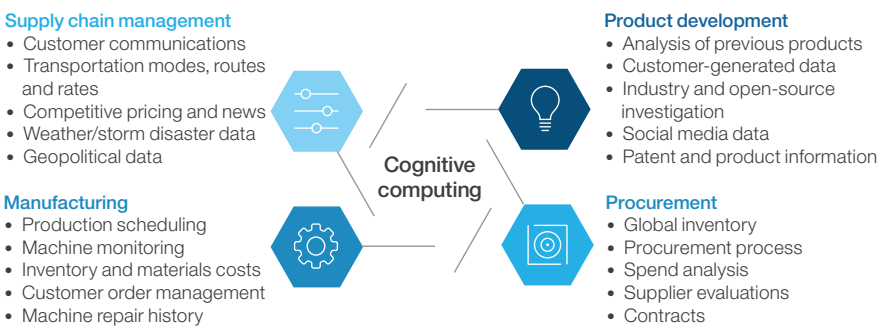
Understand your data

Data – it all begins with the data. Develop a data strategy to target information needed to address the operational problems identified in the use cases. Identify the right data sets to solve the challenge. We learned which are the most important data sets from the executives in various role capacities (see Figure 8).

Weather and other unstructured data can now be automatically analyzed to provide insight and – even better – action. For example, a building management company in the United Kingdom helps customers anticipate the weather and remotely adjust their building systems, cutting up to 50 percent of heating costs and saving 90 percent of site visits with a cognitive IoT solution.[7]

Figure 8

Cognitive computing can derive the most value from these data sets



Source: IBM Institute for Business Value

Ready your AI skillset

The nature of work is changing, and digital technologies have a lot to do with those changes. Businesses and institutions will need employees with digital problem-solving skills to drive development, growth and success in competitive markets that favor high performance levels and innovation. Basic computer technology and math backgrounds form the backbone of most AI programs. Typical knowledge and skill sets include:

- Various levels of math, including probability, statistics, algebra, calculus, logic and algorithms
- Bayesian networking or graphical modeling, including neural nets
- Physics, engineering and robotics
- Computer science, programming languages and coding
- Cognitive science theory.

It is also critical to understand the differences between data analysis and machine learning engineering. Data analysis is typically focused on dissemination – charts, models and visualizations – to be presented to a human for actionable insights. With machine learning engineering, the final output is working software, and the audience is often other software components that run autonomously, with minimal- to-no human intervention. The actionable intelligence is shifted to decisions made by machines as they affect how a product or service behaves.

Many of the companies in our case examples in this report more effectively deploy their AI and cognitive projects by engaging a Cognitive Center of Competency (CCoC) to build awareness, skills, best practices and communication plans. This is a shared service function across the organization to provide expertise in cognitive technologies and their application. The ultimate goal is to support the roadmap, communicate the AI and cognitive agenda, and strive for greater supply chain excellence.

Are you ready to experience unparalleled operational excellence?

- How will you assess the opportunities that AI and cognitive computing offer your supply chain operations and product development?
- What is your plan to integrate IoT and operational control devices as you leverage cognitive technologies?
- In what ways will you verify that your data strategy targets the information necessary to solve important business problems and operational event management?
- How can your organization collaborate to implement cognitive technologies? How will you define and measure against agreed-upon success milestones?
- What can you do to get rapid paybacks from cognitive computing, and how will you build on early results for even greater returns over time?

Study approach and methodology

We examined key streams of data for this report:

- IBM Institute for Business Value 2016 Cognitive Computing Study – We surveyed over 6,000 global executives from various industries and markets, including 1,672 supply chain, procurement, manufacturing and product development senior executives. Respondents were asked to answer questions related to the trends and challenges best served by cognitive computing, specific to their function. This paper focuses on the operations functions; forthcoming studies will explore cognitive computing in other areas of the business.
- IBM Institute for Business Value 2016 Cognitive Digital Operations Study – We surveyed over 500 executives, most of them from the operations function and all with direct knowledge of it, about how their companies are reinventing themselves to improve digital operations. This research included respondents from companies with at least USD 500 million in revenue in 11 countries around the world and across 12 industries.

For more information

To learn more about this IBM Institute for Business Value study, please contact us at iibv@us.ibm.com. Follow @IBMIBV on Twitter, and for a full catalog of our research or to subscribe to our monthly newsletter, visit: **ibm.com**/iibv.

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Related IBV publications

Butner, Karen, Dave Lubowe and Louise Skordby. "Who's leading the cognitive pack in digital operations?" IBM Institute for Business Value. November 2016. https://www.ibm.com/services/us/gbs/thoughtleadership/cognitiveops

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