# 2019 Manufacturing Trends Report

Introduction

Since the start of the First Industrial Revolution, manufacturing has been the force pushing industrial and societal transformation forward. Today, we're in the midst of another industrial revolution, as a new generation of sophisticated technologies is transforming manufacturing into a highly connected, intelligent, and ultimately, more productive industry. The manpowered shop floor of the past is being replaced by smart manufacturing facilities where tech-savvy workers, aided by intelligent robots, are creating the products of the future.

In this Fourth Industrial Revolution, machinery is outfitted with smart sensors to collect comprehensive, real-time data; artificial intelligence enables superhuman production efficiency and seamless quality assurance; blockchain transactions significantly expand transparency and security; edge computing assures nearly uninterrupted connectivity; and impending 5G speeds allow for ever-larger volumes of data processing from anywhere.

Modern manufacturers are no longer just makers, they are the thread that connects the entire lifecycle of a product, and to thrive in this modern environment, they must increasingly rely upon technology to power breakthrough innovations and drive more intelligent operations.

The following will explore six emerging trends in manufacturing that we believe will help empower manufacturers to design more intelligent operations and increase the speed of doing business.
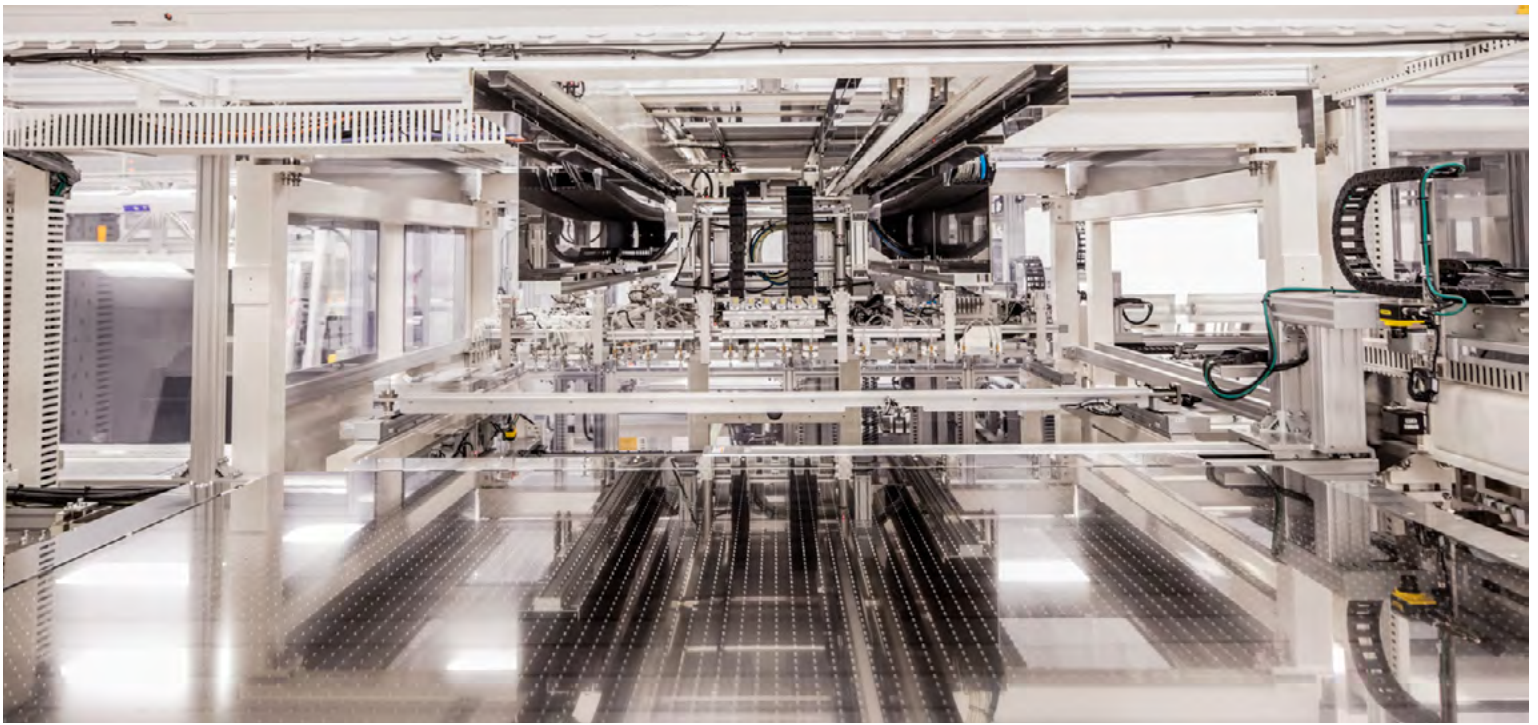
Trends

IT and OT converge

- IT and OT converge
- Businesses integrate new and legacy systems
- Industrial IoT evolves
- Businesses welcome cobots (collaborative robots)
- Manufacturing goes green(er)

IT and OT converge

In the past, the management of industrial technology in manufacturing has been divided between IT and operational technology (OT). Where IT provided top-down technology support for management and the back office, OT was built from the ground up, monitoring and controlling machinery, equipment, tools, and assets.

In this legacy role, OT has lived in a bit of a silo, where machines—manipulated by human input—were programmed to perform very specific tasks. But in recent years, advances in connectivity, big data, and the expansion of the Internet of Things (IoT) have opened the door for a new breed of intelligent manufacturing technology that is impacting both IT and OT. Today, data-optimized smart machines can receive input from a wide range of sources—from customer order data to production data—to enable more agile manufacturing, improve production efficiency, and provide greater visibility into operational performance.

For the modern manufacturer, data is no longer just the purview of IT; from supply chain management to the operations floor, data is now ubiquitous across the organization. As data becomes unified across the organization, IT and OT can no longer operate independently and, as a result, are converging.

This IT/OT convergence enables opportunities that have not been possible before. Through the integration of IT and OT data, business leaders can get access to live dashboards that provide visibility across all parts of the organization. Connected systems can communicate to detect unbalanced load flows and automatically make corrections to prevent outages. Intelligent machines can identify faulty parts and select new assets to restore production. And with integrated controls, production management systems, and supply chain management systems that are integrated with other IT systems, manufacturers are able to intelligently route orders and automate work streams.

Over the past several years, the trend towards IT/OT convergence has emerged

Executive summary

The IT systems used for data-centric computing are being merged with the operational technology (OT) systems used to control and monitor processes and devices, creating smarter, more efficient operations.

Highlights

- There are projected to be 36.13 billion connected IoT devices by 2021.

- Sales of collaborative robots are projected to increase 159% between 2018 and 2020.

Advances in connectivity, big data, and the expansion of the Internet of Things (IoT) have opened the door for a new breed of intelligent manufacturing technology.

across numerous industries, from healthcare and transportation to defense and utilities. As many of these industries rely on heavy, expensive equipment and highly specialized labor forces, the merger has been slow and tactful. But as technological advances in cloud-computing, remote sensors, and connectivity improve, it is becoming faster and easier for manufacturers to integrate the management of industrial technology and integrate new systems with their legacy systems.

In today's world of connected, intelligent manufacturing, the convergence of IT and OT is an inevitability.

In today's world of connected, intelligent manufacturing, the convergence of IT and OT is an inevitability, but that does not mean this transition comes without challenges. To start, IT and OT teams must integrate independent systems that were built and designed separately. This means finding common ground to develop new infrastructure and implementing protocols that enable data sharing across systems.

Convergence also requires security enhancements. For many manufacturers, their OT standards are proprietary and very specialized. In the past, when these systems were set up as independent, stand-alone tools, the opportunity for a breach was somewhat limited due to the tightly defined perimeters of the system. But as OT systems become connected to widespread IT communication networks, the risk of a loss increases. As such, businesses integrating the OT and IT systems must implement well defined standards that scale across their network to ensure data and IP security.

Businesses integrate new and legacy systems

The migration to intelligent manufacturing does not mean starting with a blank slate but rather effectively integrating new technology within the existing manufacturing environment. And as new technology transforms manufacturing into a highly connected, intelligent, and ultimately more productive industry, businesses must also find a way to enhance their legacy systems to keep up with emerging, increasingly sophisticated technologies.

Integrating "dumb" machines with "smart" machines starts with enabling data collection from those legacy machines. Manufacturers are increasingly retrofitting existing equipment with smart sensors that collect comprehensive data in real time. This data can then be passed to execution, production planning, and ERP solutions to provide robust visibility into performance.

As more manufacturers seek to make their legacy systems more intelligent, the market size for sensors and controllers has grown substantially and is projected to grow to $6.1 billion by 2020, up from $5.1 billion in 2016.[1] The increased availability has also driven down cost for IoT sensors. Between 2004 and 2018, the average cost of a sensor dropped nearly 200% to an average cost of $0.44,[2] making intelligent manufacturing more affordable and accessible for manufacturers of all sizes.

As manufacturers migrate operations to the cloud, companies that have invested heavily in on-premises platforms must wrestle with the challenge of leveraging these systems while simultaneously migrating more functionality to the cloud. In coming years, more companies will embrace a hybrid data center model,[3] where on-premises legacy systems are devoted to data and records functions that require little customization—as well as to storing information requiring a higher degree of control and security[4] —while those facets of a company's operations that require continuous adaptation will be diverted to the cloud. Doing so will allow companies to reduce overhead costs related to IT, to take advantage of the flexibility and economies of scale afforded by XaaS offerings, and to make continued use of legacy systems.

44¢

Average cost of a sensor in 2018, nearly 200% less than the average cost in 2004.

> **Integrating "dumb" machines with "smart" machines starts with enabling data collection from those legacy machines.**

> **Global IoT spend is projected to reach $772 billion in 2018 and surpass $1 trillion in 2020.**
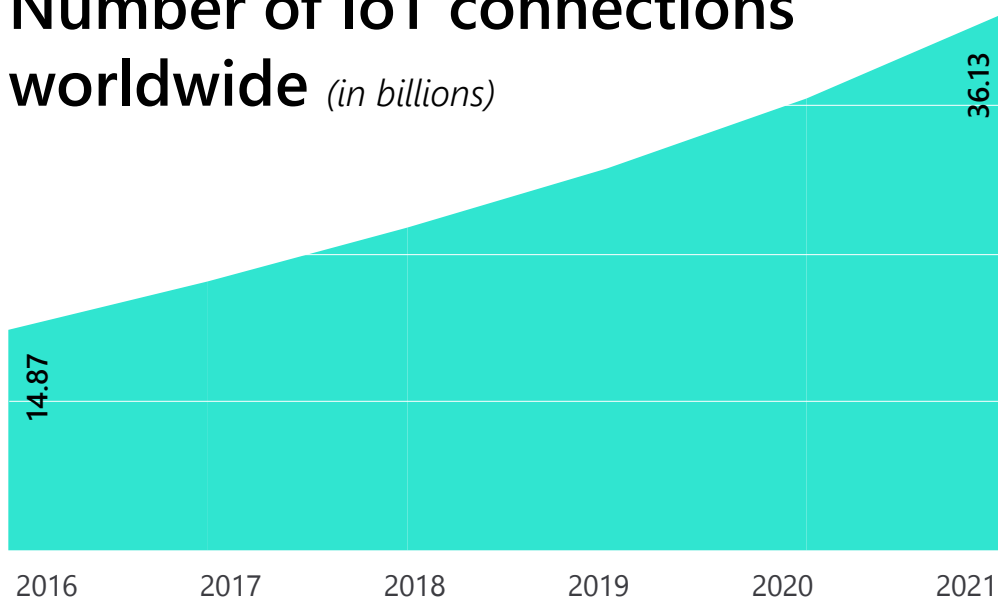
Industrial IoT evolves

The broad adoption of smart sensor technology, connectivity improvements, and advancements in cloud computing have helped drive adoption and evolution of Industrial IoT. The Industrial IoT (IIoT) is poised to have a major impact on manufacturing and the global economy, projected to create $15 trillion of global GDP by 2030.[5]

$15 trillion

IoT is projected to create $15 trillion of global GDP by 2030.

Global IoT spend is projected to reach $772 billion in 2018 and surpass $1 trillion in 2020. Manufacturers are projected to spend $189 billion on IoT in 2018, the largest amount from any industry, with the primary focus on manufacturing operations and production asset management.[6]

The IoT has many applications in manufacturing, from predictive maintenance to cloud-based artificial intelligence to machine learning, that enable superhuman production efficiency and practically seamless quality assurance. Digitization is shifting the landscape of traditional manufacturing; we are only at the beginning of this evolution, with many new opportunities ahead.

Number of IoT connections worldwide *(in billions)*

36.13

14.87

2016   2017   2018   2019   2020   2021

> **"We want to build intelligence that augments human abilities and experiences."**
>   **-Satya Nadella, CEO, Microsoft**

Businesses welcome cobots (collaborative robots)

With advancements in IoT, cloud computing, and artificial intelligence has come advancements in manufacturing robotics. Initially developed in 1995 through research grants from General Motors,[7] cobots—collaborative robots—are becoming a bigger part of the workforce. By 2025, Barclays Equity Research projects the cobot market size will reach $12.23 billion, more than an 8x increase from 2018 ($1.35 billion).[8]

The use of robots in manufacturing is nothing new, but this new generation of cobots is not your average machine. Today's cobots are built with artificial intelligence and machine learning that power cognitive capabilities. These robots are able to use computer vision to quickly inspect large quantities of items for flaws, automate the transportation of materials throughout a facility, and avoid hazards using predictive intelligence.

Cobots—collaborative by design—are being used to augment human labor rather than replace it. By taking on dangerous, physically strenuous, and repetitive tasks, these machines are making factories safer and more efficient for their human counterparts. And while many fear the loss of jobs due to automation,[9] research suggests that AI will not only improve labor safety and work conditions, but it will actually add jobs to the market.[10]

Innovations in robotics have made cobots more adaptable, compact, safer, and more affordable. They are most useful when they're powered by AI and by people that can enable their full potential. From startups to global conglomerates, manufacturers around the globe are realizing increased productivity and reduced costs by augmenting their human workforce with robot power.

Projected sales of collaborative robots worldwide
(in thousands)

2018	2019	2020
58	90	150
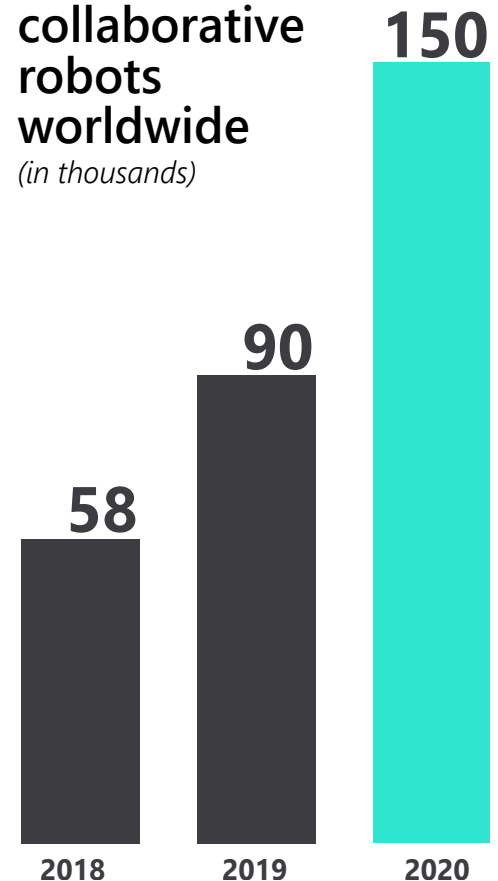
Manufacturing goes green(er)

More than ever, consumers and governments are holding companies accountable for the environmental impact of their offerings, and evidence shows that they're willing to pay for it: a study by Nielsen revealed that nearly three-quarters of all Millennials and Gen Z would pay a premium for sustainable products and services.[11] As green business practices move from the realm of moral imperative to economic driver, more and more manufacturers are taking concrete steps towards becoming environmentally conscious. This "greening" of the factory floor is happening in several ways.

Manufacturers are optimizing their facilities and production processes to reduce their overall energy consumption. This includes steps like installing energy-efficient heating and cooling systems and lighting. Improvements in energy consumption not only reduce environmental impact, but they also reduce costs.

Companies are also taking steps to reduce the amount of waste, greenhouse gases, and other pollution created as byproducts of the manufacturing process. Increasingly, manufacturers are investing alternative-energy sources, such as wind and solar, to power their operations, and using recycled, recyclable, and reusable materials whenever possible.[12]

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Many companies are also conducting lifecycle assessments of their products to evaluate the environmental impact. This includes everything from packaging design to reduce waste, product design to reduce harmful materials and improve recyclability, and the use of lean manufacturing practices to make production more efficient and environmentally friendly by reducing storage and material-management demands.[13]

Forward looking manufacturers are leaning on technology to reduce their environmental footprint. Cloud-based collaboration tools, from shared-documents to video conferencing, make it easier for teams to work together from remote locations while reducing the need to travel. Companies are now deploying computer vision and smart sensors on the production line to improve efficiency, detect hazards, and reduce waste. And blockchain technology is proving a valuable tool in ensuring the source and efficacy of raw materials.

Many large companies, from Tesla Motors and Method Soap to Apple and Proctor & Gamble, have all made commitments towards greener, environmentally sustainable practices. At Microsoft, we are proud to be a leader in this area. We have been operating at 100% carbon neutrality since 2012 and even though our datacenter are already 100% powered by renewable energy sources, we continue to work to improve our energy sourcing. Additionally, we continue to invest in new energy technology, from biogas to fuel cells, to accelerate the availability of new types of clean energy.

Improve operations

To compete in today's fast pace environment, manufacturers must work faster and smarter. At Microsoft, we are empowering manufacturers to do more with tools that streamline processes, provide greater visibility into operations, and deliver actionable insights.

Streamline operations

To meet rising customer demands, modern manufacturers must streamline operations to provide greater transparency, improve delivery times, and build better products. From productivity tools, like Office 365, to intelligent automation capabilities in Dynamics 365, Microsoft is helping manufacturers operate more effectively and efficiently.

Get greater visibility

To effectively guide their organizations, manufacturers require visibility into all areas of their business. By combining unified data in the cloud with powerful data visualization tools, like Power BI, Microsoft provides manufacturers with a single source of visibility into their operations—from the shop floor to transaction data—so they can make more informed decisions.

Be more proactive

To grow their businesses, manufacturers must look beyond the past and into the future. Microsoft empowers leaders with tools to help them identify emerging trends, predict outcomes, and automatically optimize workflows. This allows manufacturers to become less reactive and more proactive with their business strategies and operations.

The rise of XaaS

- The new X-economies
- The Servitization of Manufacturing
- Manufacturers re-evaluate their value chain
- Manufacturers move from B2B to B2B2C
- Brands go direct-to-consumer
- The gig and sharing economies grow
- On-demand and micro-manufacturing go mainstream

The rise of XaaS

The new X-economies

Millennials, burdened by high unemployment, low wages, and high debt, have rapidly embraced new business models that offer them the latest products with greater flexibility and lower costs. In today's market, startups have led the way with these new offerings, but manufacturers—either through acquisitions or internal development—are beginning to evolve their business models to the needs of the modern consumer. These models fall into one of a few categories:

On-demand services

Projected to grow to nearly $57 billion in 2018, on-demand services represent perhaps the largest of these categories.[14] A model popularized greatly by Uber, on-demand businesses are launching for just about every category imaginable, from printing and dog walkers to babysitters and massages. While many of these businesses are service based, the growth in on-demand services has also driven growth in on-demand and micro-manufacturing.

Sharing economy

The sharing economy—where consumers "share" products and services directly instead of purchasing via a retailer or distributor—is another business model that has grown in popularity over the last several years. Perhaps the most commonly known example of a sharing economy business is Airbnb, where travelers can rent homes and rooms directly from other individuals. The sharing economy is projected to grow to 86.5 million U.S. users by 2021, up from 44.8 million in 2016.[15] While the sharing economy helps reduce waste, it also poses a threat to manufacturers, as consumers may opt to "borrow" goods opposed to buying new products. As such, manufacturers are being forced to re-evaluate their business models to participate in this new economy.

Subscription box services

Subscription box services have become incredibly popular due to their highly targeted nature and ease of use. They also present a unique opportunity for manufacturers to sell direct to consumers. Companies like Birchbox, ClubW,

Executive summary

Driven by growth of the IoT and the cloud, many organizations are moving from product models to service models, giving their customers more options with greater flexibility.

Highlights

- On-demand services are projected to grow to nearly $57 billion in 2018.

- By 2021, 20% of G2000 manufacturers will depend on technologies like IoT, blockchain, and machine learning to automate large-scale processes.

- 3.9 million people regularly worked in the gig economy in 2017; by 2021, that number is projected to reach 9.2 million.

The sharing economy is projected to grow to 86.5 million U.S. users by 2021, up from 44.8 million in 2016.

Stitch Fix, and NatureBox are just the tip of the iceberg when it comes to the subscription box market, which now provides services for dogs owners, coffee lovers, mountain climbers, gold miners, and sock enthusiasts.

$57 billion

Projected size of the on-demand economy in 2018.
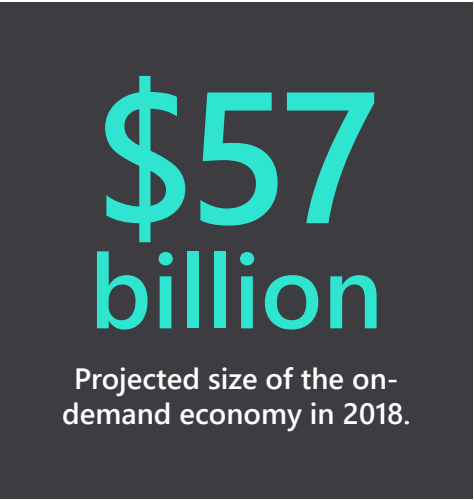
Online consignment

When eBay and Craigslist launched in the mid-1990s, they provided individuals with the opportunity to use the internet to sell used goods. Nearly two decades later, a new set of online consignment stores has emerged to help streamline this process. Sites like thredUP, Swap, and TheRealReal allow shoppers to sell and purchase used clothes, jewelry, toys, and luxury fashion accessories online. Similar to the sharing economy, online consignment stores pose a unique threat to manufacturers, and a unique opportunity for those willing to think differently about their business models.

XaaS

As cloud computing becomes more ubiquitous, Anything as a Service (XaaS) business models are also becoming more popular. The principle behind XaaS is that businesses can provide better, more cost-effective solutions to customers via subscriptions or pay-as-you-go models than via traditional software licensing models. The most commonly known XaaS model is Software as a Service (SaaS), which provides individual software applications and services through the

> **While XaaS has historically referred to cloud computing, it is increasingly being used to define all service-based business models.**

cloud; however, Platform as a Service (PaaS) and Infrastructure as a Service (IaaS) models have also gained traction as a way for technology companies to expand their footprint.

While XaaS has historically referred to cloud computing, it is increasingly being used to define all service-based business models, from Manufacturing as a Service and Product as a Service to Transportation as a Service (Uber and Lyft) and Shopping as a Service (Trunk Club and Stitch Fix). Regardless of what you call it, it's clear that customers' needs are evolving and businesses must adapt accordingly.

Sharing Economy Users and Penetration, 2016-2020

■ Adult sharing economy users   ■ % of adult internet users   *(millions and % of adult internet users)*

Year	Adult sharing economy users	% of adult internet users
2016	44.8	21%
2017	56.5	26%
2018	66.3	30%
2019	73.7	33%
2020	81.2	36%
2021	86.5	38%
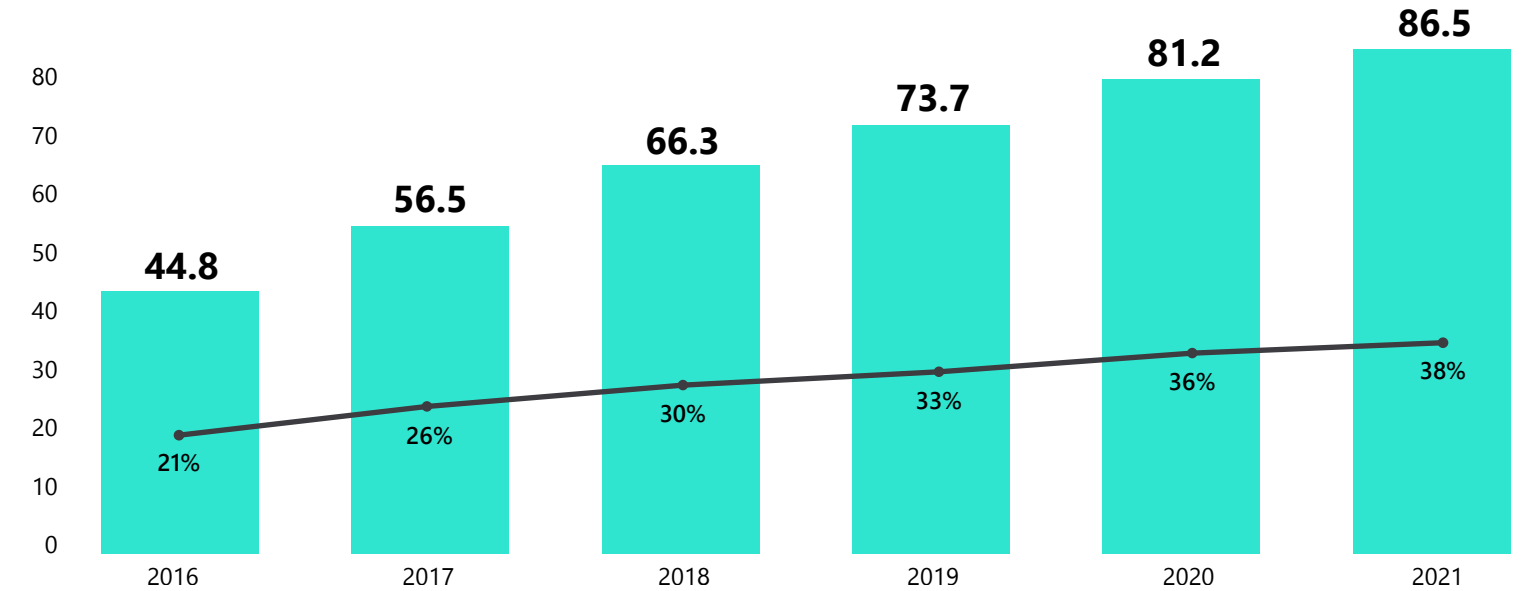
The Servitization of Manufacturing

Manufacturing has long been driven by a push for engineering excellence and operational efficiency, and over the last decade, this push has accelerated. Lower cost of entry and new technology has pushed companies to compete on product features and functionality. One needn't look farther than the availability of Bluetooth-enabled devices to see this trend in action. Today, there are nearly 2.6 million Bluetooth hearing aids,[16] 168 million Bluetooth headsets,[17] and 87 million Bluetooth-enabled automotive devices worldwide.[18]

creasingly leverage technology to improve operational efficiencies, reduce waste, and support lean production initiatives.

Today, with a market full of feature-saturated products and costs cut down to the bone, manufacturers are shifting to a more customer-centric approach, exploring new service-based business models to build value and grow relationships with customers in a modern, connected world. Adding services to their portfolios allows manufacturers to differentiate their offerings and gain a competitive edge in a rapidly changing industry.

Manufacturing as a Service

While contract manufacturing has always been a service, digitization is changing the way products are designed and the way contract manufacturers produce those products. These changes have led to the expansion of Manufacturing as a Service, where businesses can leverage a shared network of manufacturing infrastructure—from machines and maintenance to software and networking—to produce goods.

In practice, this service may be a singularly managed network of manufacturing equipment or a network of

You can get a Bluetooth-enabled toaster,[19] floss dispenser,[20] egg tray,[21] water bottle,[22] fork,[23] trash can,[24] and even Bluetooth-enabled belts that can charge your smartphone.[25]

In conjunction with the race for new features, the growth of online retail—driven by Amazon—has shrunk margins and led to cost-cutting efforts. The pressure to cut costs has made its way upstream, with manufacturers being pushed to deliver products faster, for less. This has led to some "Bluetooth-enabled belt-tightening" (pun intended), as manufacturers in-

$6 billion

Cost of a new semiconductor fabrication plant.

self-managed manufacturers. With a singularly managed network, a customer can send an order for a part, including appropriate design files and specs, and based on workload, materials, workforce availability, location, and scale, the network will dynamically route the order to a given facility, or set of facilities, to most efficiently fulfill the request. The customer may not even be aware of the routing, but they will get the benefits of faster, more cost-effective production.

With manufacturer networks, such as Dassault Systemes's 3DExperience

Marketplace,[26] customers can research and submit projects to in-network manufacturers using a standardized set of files. The manufacturers can then automatically review the designs—including the geometrics, the pathways cutting-tools will be required to make, and the materials needed—and provide fast, precise quotes to prospective customers. This cuts both the administrative burden as well as the manufacturing costs.

With faster speeds and lower costs, Manufacturing as a Service is having a significant impact on R&D, innovation, and prototyping. This impact is highlighted in certain industries that require high-tech manufacturing capabilities, such as those in a semiconductor fabrication plant (fab). New fabs cost upwards of $6 billion.[27] This cost of entry is completely unaffordable for many companies looking to enter or grow in this space; however, manufacturing fab companies, like TSMC, now offer services to do the chip manufacturing for "fabless" companies.[28] The availability of these manufacturing services—coupled with the opportunity to design and iterate new chips at a lower cost—has spawned the development of new chip design companies and many innovations in the space. Like many other XaaS business models, Manufacturing as a Service helps businesses move money from CAPEX to OPEX, freeing up capital for investment in research and development, marketing, and sales.

There are many other benefits to the Manufacturing as a Service business model, including but not limited to

faster, less expensive prototyping, helping manufacturers better balance workloads, and opening doors for manufacturers who may not otherwise have access to bid on individual projects.

Product as a Service
As manufacturers shift to become more customer-focused, many are adopting Product as a Service business models to better support their customers' needs. In Product as a Service business models, the physical products, software, and support are delivered as a service or virtualized experience, and the buyer no longer takes ownership of a physical product.

Product as a Service is nothing new—in fact, the automotive industry has been offering Product as a Service through comprehensive leasing programs for decades. In a more modern Product as a Service model, BMW is offering their cars as an on-demand service through their ReachNow program. New technology is evolving and advancing how manufacturers are offering Products as a Service, and based on some early projections, upwards of 40% of the top 100 discrete manufacturers and 20% of top 100 process manufacturers will provide Product as a Service platforms by the end of 2018.[29]

There are three primary drivers elevating Product as a Service business

Percent of top 100 manufacturers who will provide Product as a Service platforms by the end of 2018

40%

Discrete manufacturers
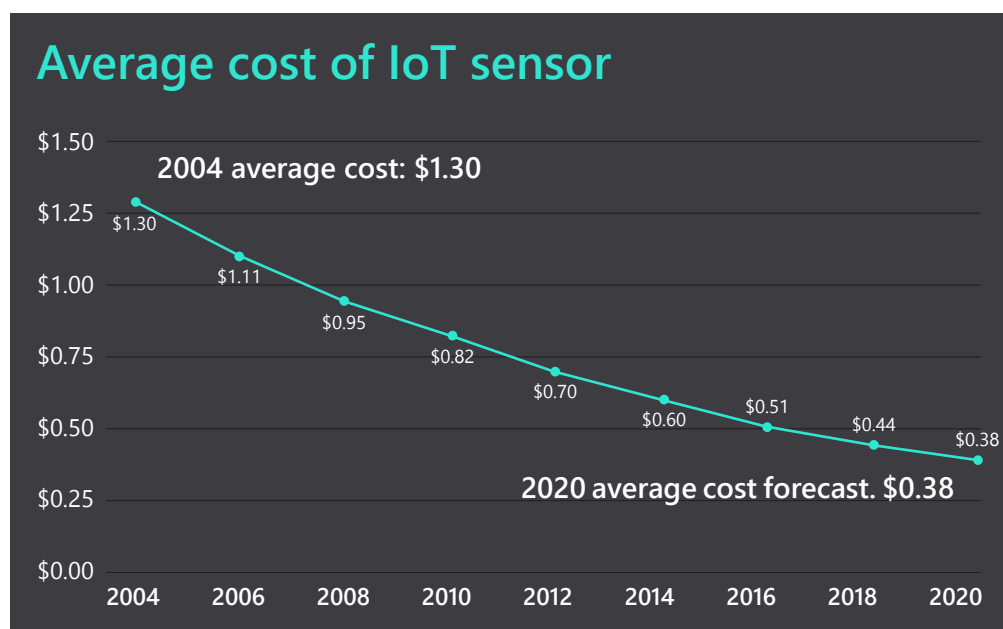
20%
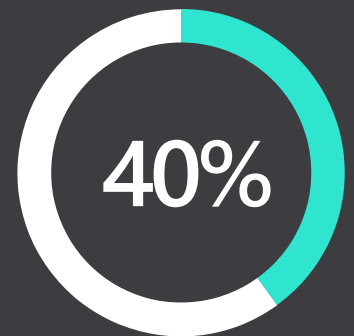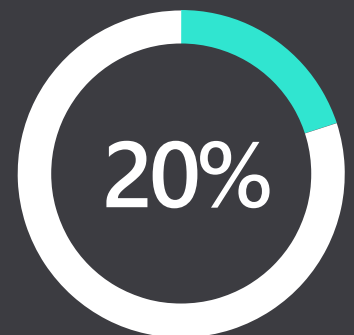
Process manufacturers

models in manufacturing. The first is easier data collection, enabled by improvements in sensor technology. Sensors have become smaller, more powerful, and less expensive—projected to reach an average cost of $0.38 by 2020, down from $1.30 in 2004.[30] With these changes, the market size for sensors and controllers has grown substantially and is projected to increase to $5.6 billion in 2018.[31] The adoption of sensors has driven easier and more robust data collection. When embedded into products, these sensors provide manufacturers with near real-time feedback about product usage. They can also be used to collect better data from across the value chain and manufacturing operations.

The second driver has been better connectivity and computer processing through the cloud. While manufacturers were certainly able to collect product and operations data before, the cloud has enabled them to more easily unify data from across all touch points within the value chain. Coupled with artificial intelligence and machine learning, this unification allows them to gain more profound insights into

their data, process information faster, and intelligently automate actions. Furthermore, modern advancements in computer processing now enable these functions to run at a scale, which was not previously possible. It can inform product development, improve sales, and enhance customer support.

The third driver is the intersection of hardware and software. As products become more intelligent and connected, it becomes harder to distinguish the product from the technology on which the product runs—particularly the software. The convergence of hardware and software ties the ongoing use of the product directly to the manufacturer, as customers may become reliant upon the manufacturer for software support and updates. This provides manufacturers with an excellent opportunity to build an ongoing relationship with customers over the lifecycle of a product, including augmenting products with digital

The sensors and controllers market is projected to increase to $5.6 billion in 2018.

Average cost of IoT sensor

2004 average cost: $1.30

$1.50		
$1.25	$1.30	
$1.00	$1.11	
$0.75	$0.95	
$0.50	$0.82	
$0.25	$0.70	$0.60 $0.51 $0.44
$0.00		$0.38

2020 average cost forecast. $0.38

2004   2006   2008   2010   2012   2014   2016   2018   2020

services, providing support, and enabling new functionality to old products through over-the-air software updates.

Digital services

As technology, such as IoT, artificial intelligence, and machine learning, provides manufacturers with greater visibility into their products and operations, they are leveraging this information to build digital services—such as predictive maintenance—that will augment their other manufacturing and product services.

ThyssenKrupp, a German multinational conglomerate and the world's fifth-largest elevator company,[32] drew upon IoT technology to connect its elevators to the cloud. Data collected from an elevator's sensors allows algorithms to process that information and predict when maintenance is required—before the elevator breaks down.[33] This predictive maintenance is further enhanced by the use of augmented reality, with elevator technicians utilizing Microsoft HoloLens to receive remote, hands-free instructions from experts while they're in the field. Initial field trials showed that elevator technicians were able to fix problems four times faster using HoloLens technology than without it.[34] By outfitting competitor elevators with their sensors, ThyssenKrupp has been able to extend this service offering beyond their existing customer base, further enhancing their competitive edge.

In addition to Manufacturing as a Service, Product as a Service, and the digital services discussed above, cloud networked manufacturing opens up a broad range of services for manufacturers to explore, including but not limited to Design as a Service (DaaS), Experimentation as a Service (EaaS), Equipment as a Service (EaaS), Simulation as a Service (SIMaaS), Management as a Service

(MaaS), Maintenance as a Service (MAaaS), and Integration as a Service (INTaaS). Diversifying offerings in this way is a key benefit for manufacturers that embrace service-oriented models. Acronyms aside, one thing seems clear: the future of manufacturing lies in customer-centric manufacturing services.

Challenges

While these service-based business models bring many opportunities for manufacturers, they don't come without their challenges. To start, many of these services require a high degree of flexibility to execute. And as many manufacturers have gone to lean manufacturing extremes, they have done so at the cost of flexibility. Thus, to deliver these services, they must restructure both operations and staff.

As these customer-centric approaches drive greater customization and personalization—such as with engineered-to-order or configured-to-order products—manufacturers must manage a growing volume of SKUs. This presents unique challenges in many different areas, from supply chain management to support. As standardization decreases and product complexity increases, manufacturers must ensure they have the right talent in place to handle production and support, an area where there are already constraints due to existing skill gaps.

An additional concern lies in the ownership of products and intellectual property (IP). Since 1998, manufacturers have cited the Digital Millennium Copyright Act—a far-reaching copyright law that governs the intersection of hardware and software—for guidance on addressing such issues. For example, the DMCA allows manufacturers to stipulate that a user who buys a smartphone is technically purchasing the hardware and a lifetime license to use the phone's operating system software. Despite the fact that

XaaS
Design as a Service Experimentation as a Service Equipment as a Service Simulation as a Service Management as a Service Maintenance as a Service Integration as a Service

the phone is useless absent the software, the customer does not "own" this software.

This lack of ownership may not seem like a huge deal for products with relatively short purchase cycles, but as expensive, highly-customized industrial products become indistinguishable from the software on which they run, there is a debate brewing around the ownership of these products in two areas. The first is around warranties. If someone made modifications to their car engine, it is reasonably understood that these alterations would void any manufacturer warranty. But this line becomes blurred as individuals seek to modify the software running their products to help customize functionality. Secondly, by retaining tight control over the software, it holds customers hostage to the manufacturer, making them dependent upon future updates lest risk their multimillion-dollar investments be rendered obsolete, not for non-functional mechanics but because of poorly functioning software. As the line between software and hardware continues to blur, manufacturers and consumers will need to establish a balance that allows for both parties to maintain appropriate levels of ownership and control.

Manufacturers re-evaluate their value chain

Consumers don't differentiate between manufacturers, brands, products, and resellers; to them, the product and the brand experience are one and the same. If a product fails, it reflects poorly on the brand. The customer doesn't know or care that the cause of the failure was a broken part that was manufactured by a third-party supplier. And if a customer has a poor support experience or a service disruption due to the failure of an externally managed software vendor, their grievance will not be with the vendor; it will be with the company whose name is on the product.

A customer's brand sentiment comes from their entire experience across the purchase lifecycle and lifespan of the product, so manufacturers must ensure excellence at every touch point. For example, efficient, transparent shipping is a key selling point for many of today's consumers. According to a recent study conducted by Temando, 49% of customers expected hyper-local delivery, and 59% of shoppers would opt to purchase an item from a brick-and-mortar store if the online competitor's shipping fees were too high. Perhaps most important, 73% of customers were brand loyal if they had a positive experience—and 50% said they would switch brands if they had a negative experience.[35]

Taking greater control of distribution allows manufacturers to have a more direct hand in creating a positive customer experience. One way businesses are taking control of distribution is by converting their retail stores into mini-fulfillment centers, which allows them to cut down on fulfillment time and avoid the expense of building new distribution centers. Rethinking fulfillment centers and distribution has the added bonus of offering greater visibility into inventory availability—something customers increasingly expect. In 2017, 58% of consumers said they expect to be able to see a product's inventory levels online, and if an item is out of stock, they expect information about when it will be back.[36] This requires businesses to track inventory across its entire journey, from the moment it leaves a manufacturing facility to its arrival at a fulfillment center to the second its delivered to a customer's door.

The pressure to perform is forcing businesses to seek tighter control over their value chain, creating greater accountability and helping to ensure that demands are met. To help meet the needs of their customers' customer, manufacturers must obtain visibility into their own supply chain, as well as have systems and processes in place for sharing this information with their business partners. Many companies have begun pursuing vertical integration to gain greater control over the parts and processes that go into their end products. This allows them to directly shape the consumer experience and better manage all touch points. Though challenging, this shift presents companies with the opportunity to prepare for the future, improve the customer experience, and decrease costs.
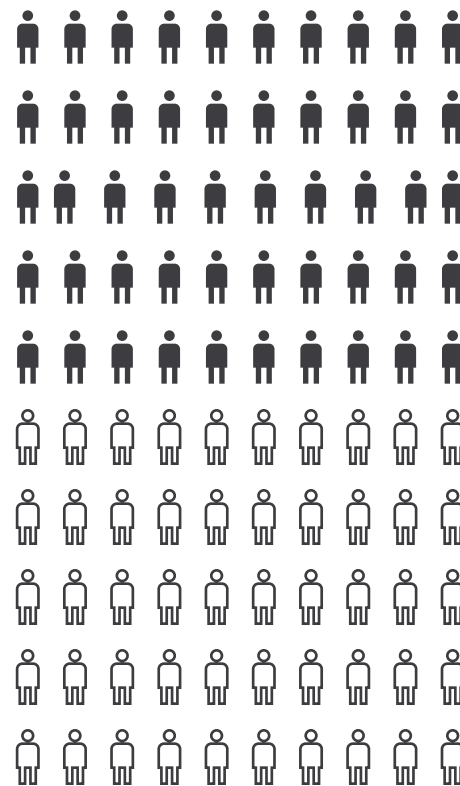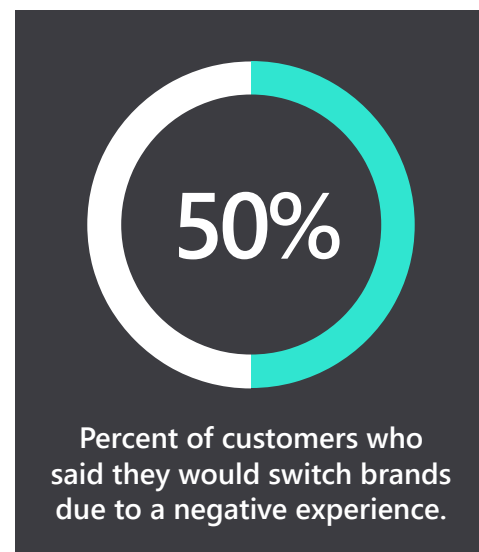
50%

Percent of customers who said they would switch brands due to a negative experience.

By leveraging technology to get closer to the end user, manufacturers can improve future iterations of the product, create a better user experience, provide superior service, and improve sales.

Manufacturers move from B2B to B2B2C

The shift to a customer-centric approach doesn't just apply to those who manufacture final products but also to businesses across the supply chain, from raw materials suppliers to parts manufacturers, who must now consider the needs of the end user and how their services impact the customer experience. To do this, modern B2B businesses must understand the end customer's journey—from discovery to purchase to service.

While these shifts have yielded clear benefits for consumers—greater transparency and better service—they introduce new challenges for traditional B2B businesses, because in order to better serve the end customer, these companies must gather more information about the end user—something historically reserved for the B2C businesses with which the customer directly interacted.[37]

Fortunately, the IoT introduces new opportunities for manufacturers to gain insight into how their products are being used. With very little effort, modern manufacturers can learn which product features are used the most, which features are not utilized, where users are getting stuck during their interaction with the product, where the product is failing to fulfill needs, where problems are likely to arise, and whether consumers are using a product in ways that it wasn't originally intended. By leveraging technology to get closer to the end user, manufacturers can improve future iterations of the product, create a better user experience, provide superior service, and improve sales.

Brands go direct-to-consumer

In order to pursue bigger profit margins and retain control of the customer experience, some manufacturers are bypassing traditional retail channels and going straight to the consumer. Cutting out the middleman allows brands to build relationships with customers and collect more accurate data. This shift, in turn, enables manufacturers to develop more personalized experiences, something that 75% of customers prefer.[38]

75%

**Percent of customers who prefer personalized experiences.**

Having achieved a valuation of $1.2 billion, eyewear manufacturer Warby Parker has succeeded with direct-to-consumer (D2C) sales, initially via e-commerce platforms and now with physical locations as well.[39] Major multi-channel brands Nike and Adidas have doubled down on their D2C efforts. Nike announced a new company alignment, the Consumer Direct Offense, that includes the creation of a Nike Direct organization, which will strategize ways to deepen one-to-one relationships with customers.[40] In 2016, Adidas launched Avenue A, limited-edition boxes that ship curated selections of women's apparel and footwear to subscribers.[41]

Direct-to-consumer subscription services have grown significantly in popularity; visits to subscription-box websites increased 890% between 2014 to 2018.[42] Arguably one of the most successful D2C practitioners is Dollar Shave Club. The men's grooming company disrupted its sector, retaining nearly half of its customers for one year after their first subscription, and was purchased for $1 billion by Unilever in 2016.[43] To compete with Dollar Shave Club and online market competitor Harry's, Gillette recently initiated its own shaving subscription club, Gillette On Demand. The new service allows customers to order refills via text.[44]

Since the cost of entry is minimal, the marketplace is already saturated with subscription services; as of early 2018, subscription box aggregator My Subscription Addition indexed roughly 3,000 boxes.[45] And now, even major retailers—including Starbucks, Amazon, Macy's, Walmart, and Nordstrom—are joining in with their own subscription box services. To succeed in this sector, subscription services must feature an offering that has the ability to surprise and satisfy customers on a recurring basis.
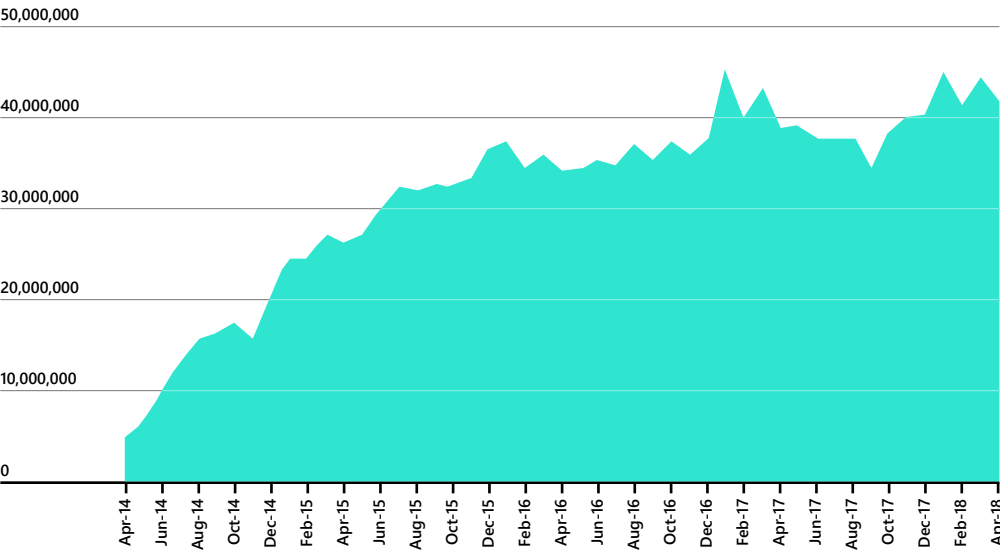
U.S. Subscription Box Industry Total Monthly Visitors

The gig and sharing economies grow

The proliferation of digital platforms and technology has made the gig economy more feasible and appealing to an increasing number of people. Thirty-six percent of the American workforce is now freelancing;[46] workers are choosing the flexibility of freelance work over the traditional perks of a nine-to-five job (such as paid time off, healthcare benefits, and retirement packages).

Intuit estimated that 3.9 million people regularly worked in the gig economy in 2017, and by 2021, they project that number will reach 9.2 million.[47] Forty-one percent of people participating in the gig economy also have a part-time or full-time job, with the extra hours they gain being used to supplement income.[48] One common misconception is that the gig economy is solely powered by Millennials. While they currently make up the largest share of the gig economy workforce, a recent survey by Payoneer reported that one in three U.S. gig workers was over the age of 50.[49]

None of this would be possible without rapid advances in technology. Cloud-based platforms make it possible for remote workers to connect with employers from anywhere in the world, and companies like Airbnb and Uber used mobile applications to radically disrupt their respective industries.[50]
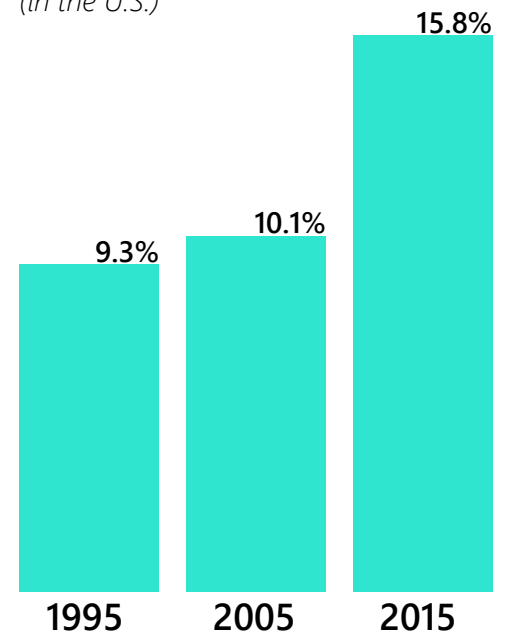
The gig economy poses a unique challenge for traditional businesses. Corporations need to figure out how to effectively engage and manage a remote portion of the workforce, as well as determine how to securely grant access to internal systems.[51] There are also concerns that a company's culture will suffer if there are too many freelance workers in the environment. However, there are substantial benefits for businesses who utilize the gig economy.

Freelancing offers corporations a more flexible and affordable means of hiring talent, especially if the company is only looking to fill a temporary need. In 2017, Samsung decided to experiment with using Upwork to satisfy needs for quick turnaround projects. This resulted in 60% cost savings and reduced administrative time by 64%.[52] Despite this, most companies still are not fully embracing freelance workers, with a recent Ernst & Young study finding that only 17% of global corporations' workforce was contingent.[53]

In its Global Corporate Sustainability Report, Nielsen found that 66%

The gig economy's size of employed

(in the U.S.)

1995	2005	2015
9.3%	10.1%	15.8%

Primary goals of personalization

Build greater customer loyalty
Target new customers with more effective digital campaigns
Increase customer satisfaction
Increase order values (e.g., cross-sell/up-sell)
Reduce customer churn with more effective experiences
Increase conversation rates
Reduce marketer effort in personalization
Increase relevancy of the brand experience; increase brand relevancy

■ Primary goal   ■ Secondary goal   ■ Tertiary goal

of consumers are willing to spend more for a product if it comes from a sustainable brand.[54] It is perhaps no surprise, then, to see the rise of the so-called sharing economy, with companies such as Zipcar, WeWork, Rent the Runway and more facilitating the reselling, renting, or sharing of items and spaces. This is not necessarily a rejection of consumerism but rather a trend toward minimalism supported by the digital revolution. Mobile technology, big data, and advanced algorithms make it possible to facilitate the sharing economy in a simple, user-friendly manner.

As the gig and sharing economies continue to grow, customers are purchasing fewer new goods. In response, many manufacturers are choosing to adopt service-based business models. Almost all vehicle manufacturers saw decreased sales in December 2017 and some were down year-over-year as well. Ford posted a 0.9% full-year decline[55] and General Motors decreased 1.3% year-over-year.[56] As more and more people move to dense urban centers, the need—and desire—to own a car dissipates. In light of these trends, and the success of such services as Uber and Car2Go, BMW introduced ReachNow, a car-sharing service that

launched in 2016 in Seattle, Portland, and Brooklyn. Consumers can choose between the BMW 3 Series or Mini Coopers—a competitive advantage over Car2Go's Smart Car fleet.[57] In an additional twist on the usual business model, the entire ReachNow fleet can switch between car-sharing and ride-sharing depending on current demands.[58] This approach allows BMW to participate in the sharing economy and to be responsive to consumers' changing needs. In March 2018, BMW and Car2Go's parent company, Daimler, reached an agreement to merge their services, indicating the success of this strategy.[59]

On-demand and micro-manufacturing go mainstream

The growth in on-demand and micro-manufacturing has been driven by decreases in the cost of 3D printing, a demand for personalization, and a growing demand for artisan goods in a world of mass-produced products.

The advent of e-commerce redefined the customer experience, allowing consumers to view and compare a wider variety of products than ever before. Today, consumers expect products that are not only customized to their market and culture but actually personalized to them as an individual.[60]

This is where micro-manufacturing comes in handy. Smaller, nimbler factories are able to more easily customize their products to client specifications. Local Motors is doing just this. A small U.S. startup, Local Motors operates five global micro-factories, where it produces items like Strati, the world's first 3D-printed car. Local Motors frequently crowdsources production designs from participants around the world, with the winner receiving a cash prize and royalties on sales of the

resulting product. This process resulted in the design of Olli, a self-driving shuttle bus powered by artificial intelligence. Local Motors' groundbreaking production model allows the company to tap into a global talent pool for new product ideas while gaining insight into region-specific needs and preferences.

Increasingly, consumers aren't just expecting customized products—they're expecting customized products nearly instantly. Candylicious, a store in the Dubai Mall, is one such company meeting this demand with custom candies that can be created in just five minutes. German candy manufacturer Katjes developed the technology, and the in-store application is so simple that children can easily operate it.[61] Another example is Ministry of Supply, a menswear store founded by MIT graduates. The company developed a machine in its Boston location that can create a custom garment on-demand in 90 minutes.

On-demand production is not only enticing for customers; it virtually eliminates inventory issues and dramatically reduces production waste.[62] Rather than guessing what the demand for a product will be, factories are able to meet the point of demand directly, producing appropriate volumes as needs arise.[63] However, despite the many benefits, micro-manufacturing has yet to be widely adopted. But that could soon change. In early 2018, Amazon received a patent for a new retailing system that would enable the company to accept online orders for custom 3D-printed items.[64] The resulting products would then be available either for pickup or delivery. As the demand for faster, more personalized products grows, so will the need for on-demand production and micro-manufacturing.

Deliver amazing experiences

Driven by new technologies and changing demographics, today's customers demand more from brands than ever before. Manufacturers must be more responsive to new trends and deliver the seamless experiences customers now expect. At Microsoft, we're helping companies meet changing customer demands with the tools and technology to better understand customer needs, become more agile, and deliver amazing customer experiences.

Understand customers

Modern manufacturers must look beyond their customers' experience and consider their customers' customer experiences. Microsoft Dynamics 365 enables companies to track product usage and performance so they can predict and prevent potential issues and create better user product experiences for the end-user.

Improve agility

Businesses must work with greater precision and agility to meet today's rapidly changing customer and market demands. By connecting data from across the value chain, Azure and Dynamics 365 help organizations improve communication across the value chain, predict and respond more rapidly to trends, and better manage changes on the fly.

Exceed expectations

As the baseline for service continues to climb, manufacturers must rely on technology to deliver the amazing experiences that customers expect, at scale. Microsoft is empowering organizations with the tools and technology to create innovative, frictionless experiences to delight customers and exceed expectations every time.

Manufacturing becomes intelligent

- A brief history of manufacturing
- Industry 4.0 and intelligent manufacturing evolve
- AI and ML deliver instant intelligence
- Ubiquitous computing becomes the norm
- Blockchain becomes more than just a buzzword
- Intelligent Supply Chains emerge

Manufacturing becomes intelligent

A brief history of manufacturing

In the early 1700s, European and American societies were predominantly rural and agrarian. The majority of goods were made in the home or obtained by trading with members of the local community. But by the mid-1700s, this model began to change.

The textile industry—which once required natural fibers to be spun into thread and then hand woven to make fabric—was transformed in 1764 by the development of the spinning jenny ("jenny" being short for the word "engine"), a machine that could produce multiple spools of wool at once. In 1768, Richard Arkwright created a version of the spinning machine that was powered by a water mill. This combination of power, machinery, and semi-skilled labor led to the development of the first modern factory systems and a wave of innovation known as the Industrial Revolution.[65] [66]

The First Industrial Revolution spawned the growth of industrial and urban societies. Factories and powered machinery lead to major innovations in the iron and textile industries, and the development of the steam engine played a central role in the dissemination of goods, a task that was previously both slow and expensive.

The 50 years leading up to World War I marked the Second Industrial Revolution, when electricity was first used to power mass production. This era of innovation spawned advancements in the telephone, light bulb, and internal combustion engine.

The Third Industrial Revolution was characterized by the migration from analog electronics to digital technology. From the personal computer to the internet, the Third Industrial Revolution has given rise to many of the devices and platforms on which we rely today.[67]

Executive summary

Augmented with smart sensors and advanced data processing, manufacturing is more connected and intelligent than ever.

Highlights

- By 2021, 20% of G2000 manufacturers will have moved to an intelligent manufacturing model.

- Businesses will generate $2.9 trillion in business value from AI by 2021.

- Twenty-three percent of businesses are currently using blockchain technology.

From the personal computer to the internet, the Third Industrial Revolution has given rise to many of the devices and platforms on which we rely today.

Industry 4.0 and intelligent manufacturing evolve

Now, nearly two hundred and sixty years after the start of the First Industrial Revolution, we are in the midst of the Fourth Industrial Revolution, often referred to as Industry 4.0.[68] Industry 4.0 is marked by automation and data exchange in manufacturing technologies, including cyber-physical systems, the Internet of Things (IoT), cloud computing, and cognitive computing.[69] Together, these developments have resulted in a new era of smart factories and intelligent manufacturing.

Intelligent manufacturing combines self-monitored manufacturing processes and machines, automated quality assurance of final products, and insights from outside the manufacturing process. In this new model for manufacturing, AI-enhanced computers are able to detect and report on physical processes happening in the real world and make human-like decisions in real time, sometimes referred to as a "cyber-physical production system." And cloud-based monitoring and management enable up-to-the-minute intelligence on asset function and health, facilitating predictive maintenance and servicing to avoid breakdowns and associated downtime.

Intelligent manufacturing isn't just about data; it's about using data to make automated decisions, predictions, and real-time optimizations across the end-to-end value chain. As with previous waves of the Industrial Revolution, Industry 4.0 promises to dramatically reshape how we make and deliver goods. This technology is being used to bring down labor costs, reduce product defects, shorten unplanned downtimes, improve transition times, and increase production speed—all while making manufacturing more flexible.

Intelligent manufacturing also prom-ises to make industrial settings safer for human workers by leveraging technologies such as video, images, sensors, GPS data, and augmented reality. By adding 7,000 sensors to its remote-controlled extraction device, mining equipment manufacturer Joy-Global created a machine that could be sent into areas that were too dangerous for human workers.[70]

Given the many benefits, it's no surprise that businesses are adopting intelligent manufacturing. IDC predicts that by 2021, 20% of G2000 manufacturers will have transitioned to intelligent manufacturing, reducing execution times by up to 25%. IDC also reports that by 2019, 50% of manufacturers will crowdsource product ideas and improvements directly from customers, improving product success rates by as much as 25%.[71]

Industry 4.0 has the potential to be a powerful driver of economic growth, predicted to add between $500 billion-$1.5 trillion in value to the global economy between 2018 and 2022.[72] These new technologies and practices will help factories and supply chains become progressively more efficient. McKinsey predicts that machine learning will reduce supply chain forecasting errors by 50% and reduce lost sales by 65% because of better product availability.[73] Over the next five years, companies that have embraced intelligent manufacturing will see annual improvements in efficiency that are seven times higher than the average rate of growth since 1990.[74]

The most exciting outcome of Industry 4.0 isn't in how it changes the day-to-day operation of factories but rather in its potential to transform how companies relate to partners at every level of their value chain. With Industry 4.0, companies can expect to have vertical and horizontal system integration, where firms, suppliers, and even customers are more tightly integrated thanks to robust data sharing.

Industrial Revolutions

Late 18th century
First Industrial Revolution
Power generation

Beginning of 20th century
Second Industrial Revolution
Industrialization

1970s-2000s
Third Industrial Revolution
Electronic automation

2010-present
Fourth Industrial Revolution
Intelligent automation

AI and ML deliver instant intelligence

Not long ago, artificially intelligent machines seemed like a thing of science fiction; even today, when people think of artificial intelligence (AI), many still envision human-like robots. But in practice, artificially intelligent machines have been around for decades, making our lives better, safer, and more efficient. So why all the buzz now?

In short, it's because these systems are only now getting really good. Correction: really, really good. In 2016, Microsoft's Artificial Intelligent and Research team reported that their conversational speech recognition system had reached human parity, i.e., their system made the same or fewer errors converting speech to text as a professional transcriptionist.[75] This system, which boasted a word error rate (WER) of 5.9% in 2016, has since improved to a WER of 5.1%.[76] As the processing power and accuracy of these intelligent systems improve—with advances in technologies rang-

ing from neural networks to natural language processing—the opportunities to leverage these technologies increase as well.

To understand how artificial intelligence and machine learning will impact manufacturing, it's first useful to understand what these terms mean. While there are many types and definitions of AI, it can commonly be understood as a computer that performs a function that requires some form of cognitive intelligence. This may include visual perception, speech recognition, or decision making. Machine learning is a type of artificial intelligence where computers leverage new information to improve their outputs automatically.[77]

The power of these intelligent computers—which are increasingly cloud-based—is in their ability to process a large volume of information at a speed which humans are not capable of achieving. While reaching human parity in WER is excellent, the true power of this artificially intelligent system is that it can transcribe hours of

audio in seconds at that same WER. This proficiency makes artificially intelligent computers extremely effective in performing four categories of tasks: detection, classification, probability, and optimization.

Detection

Intelligent systems can be used to analyze large amounts of data and detect anomalies. In manufacturing, this may be used to help identify faulty products, to predict when a machine will need maintenance, or to detect potential safety issues in and around a factory. These tools are also being used to help mitigate risk by ensuring regulatory compliance and improving operations, flagging abnormal changes or anomalies for further investigation.

Projected global intelligent manufacturing market size
(in billion U.S. dollars)
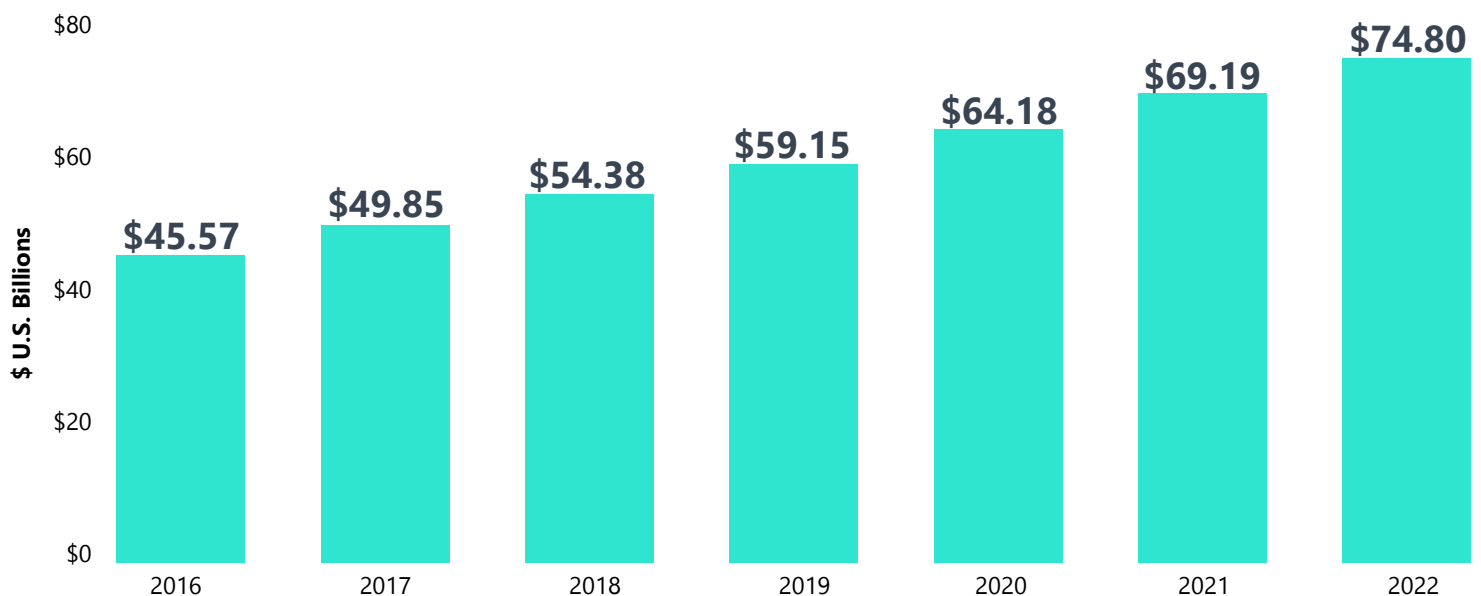
Classification

Artificially intelligent systems can be used to organize and classify data categorically. Through classification—sometimes referred to as segmentation or clustering—businesses can leverage AI to sort materials, reconcile transactions, categorize expenses, and even look for interactions between categories to identify correlations.

Probability

AI systems can be used to conduct probability analysis. These tools give managers the ability to run faster, more accurate data models. This enables them to quickly test how changes to specific variables will impact outcomes, such as how making changes to the production line will impact output or how adjustments to a product formula will alter product performance.

Optimization

Lastly, these tools can be used to optimize systems, processes, and decision making. Through real-time data analysis, intelligent systems can calculate the probability of various outcomes and adjust accordingly. For example, in manufacturing, analytical models can be used to reduce injuries by slowing down a machine when a sensor identifies a potential issue, or it can cut costs by automatically changing resource allocation across the organization to minimize waste.

Despite its many benefits, just 15% of businesses are currently leveraging AI, but 31% are planning to implement intelligent systems over the next year.[78] Eighty-three percent of companies said that AI is a strategic priority for them.[79] As organizations reap the efficiencies and insights of AI, Gartner predicts that businesses will generate $2.9 trillion in business value from AI by 2021.[80]

$2.9 trillion

Business value generated from AI by 2021.
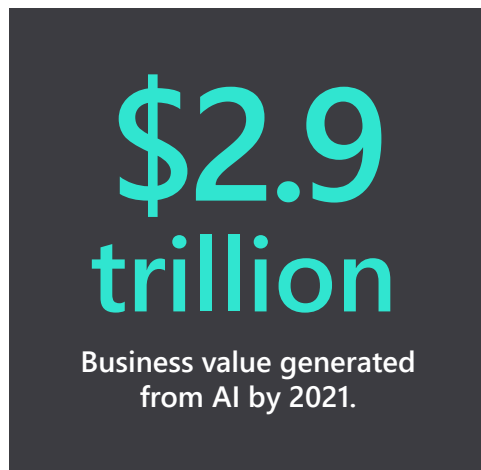
The merging of big data with new technology has made processing large data sets easier than ever, and from mining big data to predictive analytics, manufacturing leaders are increasingly relying on these new, intelligent tools to help them succeed. AI gives manufacturing leaders an incredible degree of insight into operations and the market, allowing them to assess consumer data to forecast purchase and usage behavior, to review economic indicators to predict market trends, and to evaluate operations metrics to help streamline processes and cut costs.

31%

Percent of businesses planning to implement intelligent systems over the next year.

Artificially intelligent computers are extremely effective in performing four categories of tasks:
detection, classification, probability, and optimization.

Ubiquitous computing becomes the norm

Computers are everywhere, and they are increasingly connected, enabling smart devices, smart rooms, smart homes, smart buildings, and smart cities. This new level of ubiquitous connectivity and computing is providing new opportunities for manufacturers to develop smart factories and track products through their lifecycle.

Much of these advancements have been powered by near-ubiquitous internet, the cloud, and the IoT. As these technologies continue to improve, through 5G networks and edge computing, they are moving us towards an era of ambient intelligence where everything around us is smart and connected.

5G makes an introduction
New 5G networks will be a huge boost to intelligent manufacturing, accelerating businesses ability to process massive amounts of real-time data quickly and from virtually anywhere.

As manufacturers increasingly adopt service-based business models, the ability to have high-speed internet, anywhere, is critical for business success. Not only does it provide field service reps with fast access to information, but it also enables IoT sensors and devices to stay reliably connected to the network.

Processing the massive amounts of data generated by the thousands of devices and sensors embedded in a smart factory requires a lightning-fast industrial wireless network. Emerging 5G technology, which is expected to be available worldwide in 2020, will be critical to the success of intelligent manufacturing. With the theoretical potential to deliver download speeds of up to 10 gigabits per second, 5G

will boast latency rates as low as four milliseconds, making it capable of transferring large amounts of data quickly enough to enable real-time AI decision-making.

Manufacturers connect at the edge
Cloud computing is revolutionizing the way manufacturers do business, but there are some cases where cloud computing can have limitations, such as latency, bandwidth, and a lack of offline access. To solve for these limitations, many manufacturers are turning to edge computing. Edge computing allows manufacturers to run appliations and store data with on-premises infrastructure that is connected to the cloud.

Manufacturers are embracing edge computing for several reasons. First, using edge technology reduces the amount of data that has to be sent over the network. This speeds up decisions and brings response times to mere milliseconds and reduces cloud computing costs.

And by retaining data and analytics on premise, edge computing minimizes the risk of interruptions to production due to network outages. Going forward, expect to see manufacturers embracing hybrid solutions that make use of edge computing where speed, continuity of operations, or privacy are of the essence while using the cloud in instances where it's necessary to analyze large volumes of data pulled from disparate sources across the supply chain.

5G networks have the potential to deliver nearly 10,000 Mbps.

Hybrid Cloud Market CAGR
(in billions)

Year	Value
2014	$25.28
2015	$32.18
2016	$40.97
2017	$52.15
2018	$66.39
2019	$84.67

Blockchain becomes more than just a buzzword

First described in 1991 by Stuart Haber and W. Scott Stornetta,[81] blockchains are decentralized, shared ledgers where all transactions are recorded securely in near real-time and are immutable (incapable of being altered or deleted). Blockchain technology sparked a revolution in 2009 when Satoshi Nakamoto leveraged blockchain to provide the data structure for a novel peer-to-peer electronic cash system, Bitcoin.[82]

Despite blockchain being nearly three decades old, we are still in the early adoption phase of blockchain, but this technology is expected to grow rapidly over the next six years,[83] with the global blockchain market projected to reach a value of $20 billion by 2024.[84] A World Economic Forum survey reported that 10% of global GDP will be stored on blockchain by 2027.[85]

Even today, attitudes are changing fast. In AFP's 2017 MindShift Survey, only 1% of organizations had implemented blockchain, while 51% reported no plans to do so.[86] By their 2018 report, 23% said they were currently using blockchain technology,[87] a huge year-over-year leap.

> **The global blockchain market is projected to reach a value of $20 billion by 2024.**

While blockchain has become popular due to its efficiency in processing financial transactions, companies are already looking to blockchain to solve other business problems, including a number of areas impacting manufacturing. For example, a blockchain can connect ledgers from across an organization's supply chain (supplier, manufacturer, distributor, shipper, retailer, and end consumer) to improve the accuracy and efficiency of tracking a product's journey.

Tracking a product's journey via blockchain can turn a manual process that once took days into an automated process that takes only seconds,[88] and the immutable record keeping in blockchain makes it a great tool for tracking temperatures across a cold chain, quality assurance, warranty remediation, and fraud. And this is just the beginning.

A number of blockchain solutions now enable companies to build anti-counterfeit databases, track stolen products, or track items with specific qualities, such as diamonds from conflict zones or luxury products that rely on product authenticity.[89] One promising application of blockchain is with contract and document management—digitizing and moving the governance of paper certificates, warranties, and contracts into a blockchain—which can automatically update the documents when a triggering event occurs. And testing has already been implemented in the food safety industry, where blockchain allows food to be granularly tracked, so when a producer identifies an issue—like a tainted batch of spinach—they can contain the problem by isolating the source

23%

Businesses currently using blockchain technology.
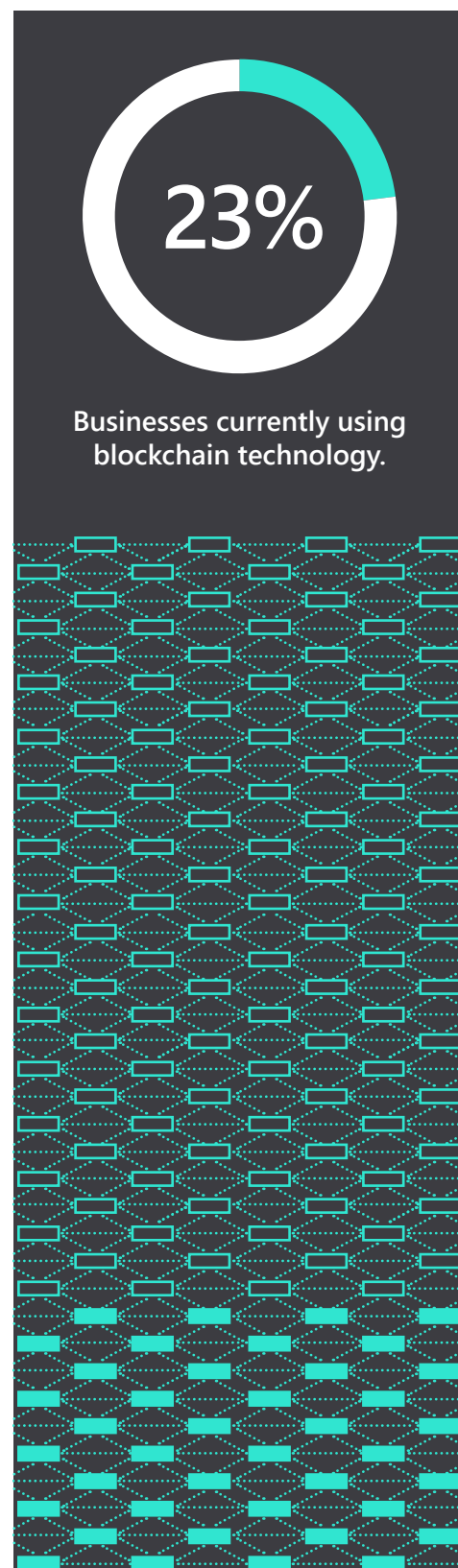
and issuing a recall for only the affected products.

Businesses are poised to see significant returns from blockchain. A recent study from Accenture reported that blockchain could help cut costs and deliver savings of more than 30% across the middle and back office. This includes an estimated 70% savings on central finance reporting and 50% savings on compliance, centralized operations, and business operations.[90] Many of these savings are due to streamlined processes, optimized data quality, improved transparency, and better internal controls.

Other potential benefits of employing blockchain technology include reduced risk of fraud, reduced time to complete transactions, better networked loyalty programs, and increased customer trust. Modern manufacturers must understand blockchain and the possibilities offered by this disruptive technology.

Intelligent Supply Chains emerge

In conjunction with intelligent manufacturing, these advancements—from AI to ubiquitous computing to blockchain—are enabling intelligent supply chains. AI and machine learning are powering intelligent, autonomous systems that can streamline processes at or in-between any stage of the supply chain.

Ubiquitous connectivity and computing are improving communication across the supply chain, and blockchain will provide greater transparency and trust.

Intelligent supply chains enable seamless synchronization between supply, demand, and fulfillment. It provides real-time visibility across the supply chain and manufacturing operations, while facilitating collaboration, and in doing so, it can improve forecasting, optimize inventory levels, and make operations more efficient, saving time and money.

Work faster and smarter

From smart factories to intelligent supply chains, manufacturers are leveraging new technology to meet evolving market needs. To meet these changing demands, they must leverage innovative, intelligent tools to optimize performance while fostering growth. At Microsoft, we're making manufacturing smarter and safer with unified data that powers intelligent, automated systems.

Unify business data

Manufacturers need real-time visibility into operations and performance to make informed decisions. From cloud-based data solutions on Azure to intelligent analytics tools in Dynamics 365, we're helping manufacturers turn data into actionable insights so they can optimize operations and make more strategic business decisions.

Get predictive insights

To succeed in today's competitive business environment, manufacturing leaders require more accurate forecasts and foresight into emerging market trends. With artificial intelligence and machine learning embedded, Dynamics 365 provides manufacturers with the data and knowledge to better predict trends, optimize processes, and grow their business.

Automate workflows

As the pace of modern business accelerates, manufacturers are looking to streamline processes and get more done. With Azure, Dynamics 365, and Office 365, we're providing manufacturers with tools to automate workflows and simplify communication so they can improve efficiency, safety, and productivity.

Manufacturing technology evolves

- Manufacturing meets its (digital) twin
- Additive and subtractive manufacturing continue to improve
- Autonomous devices improve workflows
- Advanced materials unlock new opportunities
- AR/VR shines in manufacturing

Manufacturing technology evolves

Manufacturing meets its (digital) twin

A digital twin is exactly what it sounds like: a digital replica (simulation) of a real-world system. By combining data with artificial intelligence, machine learning, and software analytics, digital twins update and change along with their physical counterparts, almost in real time. Digital twins can be used to mirror complex pieces of machinery, predicting how they'll respond to certain scenarios. They also allow manufacturers to have faster, less expensive R&D cycles, create safer, higher-quality products, and ultimately facilitate better decision-making.

A number of manufacturers have already incorporated digital twinning to work more effectively and efficiently. General Electric's (GE) power and water division implemented digital twins for parts it supplies to power plants, wind farms, and electrical grids. IoT sensors and controls on the physical parts send signals to digital simulations, allowing plant operators to almost immediately know the parts' condition, optimize power, and figure out if maintenance is necessary. Operators can also use the digital twins to simulate various conditions and determine how they might affect their real-life counterparts.[91] And using HoloLens, engineers at GE are using augmented reality to look inside and interact with these digital twins without physically touching them.[92]

Digital twins are particularly useful for large, complicated parts—such as jet engines, an incredibly complex piece of technology. Rotating blades within a jet engine are exposed to temperatures up to 3,000° F. (Most metals melt between 2,000–2,500° F.) Even when the right materials are used to solve for these challenges, the reality is that jet engines still require regular maintenance to protect them from ongoing wear and tear. However, the maintenance schedule for each engine is not necessarily the same; various factors such as airport conditions, the number of people on a flight, and a pilot's flying style all impact how quickly an engine degrades. Rolls-Royce is using digital twins to better understand how engines operate under extreme conditions, including how they would perform after losing blades.[93] These types of test enable Rolls-Royce to design better, safer jet engines that will operate predictably even in the most extreme of circumstances.
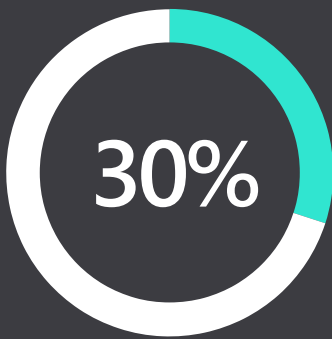
Executive summary

Manufacturing technology continues to evolve, unlocking new opportunities to improve manufacturing processes, better support employees, and create new, innovative products.

Highlights

- Two-thirds of U.S. manufacturers reported deploying 3D printers in some capacity.

- By 2025, spending on robotic systems will reach $67 billion.

- 3.5 million manufacturing jobs will open up in the next decade in the U.S., and 2 million of them will go unfilled.

Digital twins are a digital replica (simulation) of a real-world system.

30%

Percent of Global 2000 companies that will use digital twins and IoT-connected products to improve product innovation and organizational productivity by 2020.

Customization is another potential benefit of digital twins. More and more, customers expect to be able to customize and personalize products to their own specifications. In the past, however, incorporating customer input into the design process has been cumbersome, time-consuming, and expensive. Digital twins allow product designers to quickly and easily test out different product variations, seeing how they would work in the "real world."[94] Collected usage data from IoT-enabled products also allows designers to improve upon future iterations. IDC predicts that by 2020, 30% of Global 2000 companies will use digital twins and IoT-connected products to improve product innovation and organizational productivity, achieving up to 25% gains.[95]

Clearly, incorporating digital twins into a manufacturing environment requires forethought and a sometimes significant upfront investment. However, the benefits can be substantial. An issue discovered during integration and commissioning phases requires 60–100 times more effort to resolve than if it's discovered during the conceptual and design phases. Digital twins make early discovery much more likely and can reduce costs by 50–100%.[96] According to Gartner, half of large industrial companies will use digital twins by 2021, resulting in a 10% overall improvement in effectiveness.[97]

We're still in the early stages of digital twins, but the prospects are bright as businesses explore new uses for them. Product twins can enable an automotive manufacturer to maintain a digital twin of every car, which can help predict and solve maintenance issues. Process twins can be created to test the impact of operational changes. And environment twins can run tests to measure environment impact (on whatever the "environment" may be). Whatever the use, digital twins appear to open the door to faster testing, less waste, and better, safer products.

Additive and subtractive manufacturing continue to improve

Changes in subtractive manufacturing and the growth of additive manufacturing continue to disrupt businesses of all sizes, often resulting in faster production and lower costs. Additive manufacturing—synonymous with 3D-printing—constructs parts by successively depositing layers of material in a predesigned shape. A more traditional approach, subtractive manufacturing creates objects by cutting away pieces from a solid block of material, a process typically done with a CNC machine. Hybrid manufacturing is a combination of these two approaches and represents a growing trend.

Additive manufacturing has been a buzzword within the industry for quite some time, but it's now beginning to gain momentum. Smithers Pira reports that the additive manufacturing market is expected to reach $55.8 billion by 2027.[98] In 2017, a growing number of original equipment manufacturers (OEMs)—including Stryker, Caterpillar, and Airbnb—began investing in additive manufacturing. (Boeing and General Electric had already done so, leading the charge.)[99]

One of the benefits of additive manufacturing is the ability to create custom or specialized products at much lower costs. For example, spinal surgeons may require specialized tools based on a particular surgical technique or patient population. Previously, developing such a niche tool would be cost-prohibitive. Today, technicians at EOS's North American technology innovation center in Austin, Texas, can use 3D-printing to produce custom stainless-steel surgical tools quickly and easily.[100]

The aerospace industry is another that benefits from the speed and agility of additive manufacturing. Traditionally, creating an aerospace tool or mold takes six months to a year (or more); with additive machines, manufacturers can design a part, print a tool, and produce the part in just one week. Another important benefit: manufacturers are not locked into a particular design. If an adjustment is needed, it's easy to reprint the part with that modification.[101]

Up to this point, additive manufacturing has not replaced traditional methods such as subtractive manufacturing, nor is it likely to anytime soon. Subtractive manufacturing is more efficient and accurate for creating certain design features—such as holes—whereas additive manufacturing typically uses much less material to create a product, which is clearly a benefit.[102] Oftentimes, manufacturers find that combining additive and subtractive manufacturing results in better outcomes. For example, automotive seat supplier TS Tech built a check fixture using both 3D-printing and CNC machining, which resulted in cutting costs by 31%.[103] Some companies have begun capitalizing on this trend and are selling machines that combine the two processes into one single unit—so-called hybrid manufacturing.[104] In the future, we'll likely see companies continue to find ways to incorporate additive manufacturing into current processes to create the most effective outcomes.

$56 billion

Projected size of additive manufacturing market by 2027.

Autonomous devices improve workflows

Autonomous devices are enhancing workflows across the supply chain, from improving shop floor operations to facilitating intelligent distribution management. While robots have been common in manufacturing for quite some time, artificial intelligence is powering a new breed of autonomous devices, ones that are able to operate with little or no human interaction. More advanced models are able to learn from their surroundings and make decisions independently, greatly increasing their potential uses.[105]

In 2005, businesses spent $11 billion on robotic systems, worldwide; by 2025, the Boston Consulting Group expects that number to reach $87 billion.[106] This investment indicates the huge potential for autonomous technology. It is increasingly common for autonomous drones and robots to locate and transport materials around warehouses and even deliver products to customers.[107]

However, the full impact of this technology has only just begun. Autonomous devices have the potential to revolutionize a wide range of manufacturing industries. European robotic-device company KUKA has a full line of industrial robots designed for a variety of purposes, including heat- and dirt-resistant robots for extreme conditions, ideal for the foundry and forging industry; hygienic, highly precise robots that meet food-safety and pharmaceutical standards; and robots that are designed to collaborate with humans on highly sensitive tasks.

Human-robot collaboration is perhaps the next big step for these autonomous devices. Improvements in sensors, AI, trainability, and dexterity have made autonomous robots not only more effective, but also safer, which means they're now more able to work alongside humans with less risk of malfunction or injury.

The growth of autonomous machines doesn't mean replacing their human coworkers; autonomous robots are prime candidates to take over monotonous or dangerous tasks, allowing humans to shift to safer, higher value work.[108] This does mean, however, that the number of unskilled jobs requiring repetitive tasks will likely decline worldwide. The Boston Consulting Group anticipates this will result in a shift in manufacturing locations, with more companies looking to locate factories in countries that have the knowledge and infrastructure to enable autonomous technology.[109]

Despite the potential uses and advantages, adoption of autonomous devices has been relatively slow. Only 9% of manufacturers currently use semi-autonomous or fully autonomous devices within their operations; an additional 11% expect to use them within the next three years. Manufacturers cite cost as a key obstacle in implementing autonomous devices in their workplaces—60% cite it as a top concern.[110]

However, as technology progresses, prices are dropping. In 2010, a single industrial robot cost $150,000 on average; by 2015, that number had dropped to $25,000, an 83% decrease over five years.[111] Deloitte predicts that within the next ten years, autonomous devices will provide a competitive advantage to companies that incorporate them into the workplace.[112] As autonomous devices become more advanced, less expensive, and as manufacturers become more confident in their ability and value, an increasing number of companies are likely to implement them.

Cost of an industrial robot

● = $1000

2010

2015
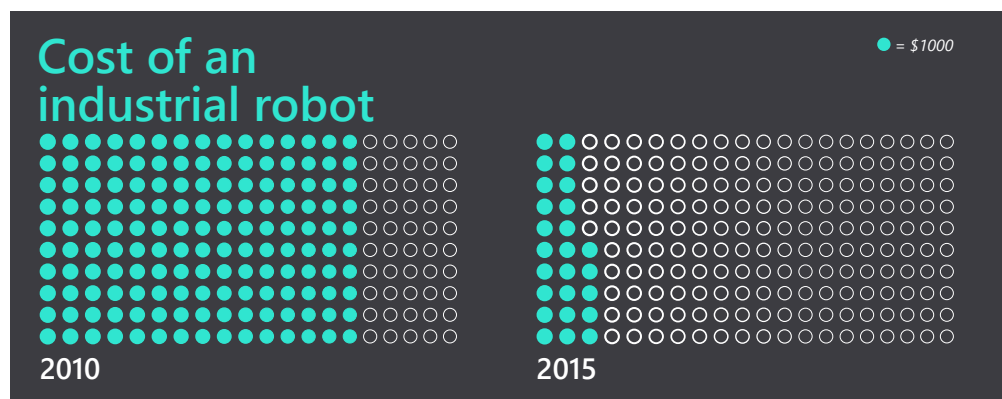
Advanced materials unlock new opportunities

Breakthroughs in robotics, sensors, and computing technology have not only affected how products are made, but the very material used to create them. Advanced materials today include everything from super-strong composites and exotic alloys to materials that seem straight out of a sci-fi movie—such as bio-materials that can "heal" themselves and lightweight fabrics that can solidify with a single touch.

Computer modeling tools now enable companies to design materials with the exact properties they're seeking, in a much more efficient and cost-effective manner than traditional R&D trials. For example, the International Centre for Advanced Materials at the University of Manchester has been able to use secondary ion mass spectrometry to study how hydrogen atoms diffuse into steel, revealing any flaws and allowing for the development of a stronger product. In the past, finding similar results would have taken months of trial and error; now, it takes an afternoon.[113]

Nanotechnology allows scientists to manufacture materials at the molecular level, which has the potential to transform a wide variety of products. Nanoparticles are able to take on unique physical, chemical, mechanical, and optical qualities; scientists can take advantage of this by incorporating nanoparticles into materials. Nanotechnology allowed for the creation of lithium-ion batteries, which revolutionized the smartphone industry, and improvements are still being made on batteries for electric cars, domestic robots, and more.[114]

Materials that once would never have seemed possible are now becoming a reality. Polish scientists at the Moratex Institute of Security Technolo-gy developed a liquid that instantly hardens on impact—the ideal material for body armor. While it was developed specifically for the military, this Shear-Thickening Fluid has a number of other potential uses, including protective sports gear, car bumpers, and protective road barriers.[115]

Advancements in computing power have also had a huge impact on the field of materials development. Researchers are now able to explore the properties of a virtual material without having first to produce it. The Materials Project utilizes supercomputers to compile the properties of all known and predicted compounds, creating an open-access resource for anyone to use. Their ultimate goal is to remove the guesswork from materials development. Rather than starting with a material and figuring out if it has desired properties, a manufacturer can determine the desired properties—such as conductivity, hardness, and elasticity—and easily search for a material based on those requirements.[116]

While they can be initially costly to develop, these new advanced materials offer substantial benefits for manufacturers. For example, the aerospace industry is continually seeking ways to make aircraft lighter, stronger, and more heat-resistant, all of which results in increased fuel efficiency, faster speeds, and lowered emissions. A huge leap forward for the industry was the development of carbon-fiber composites—stronger than steel and one-fifth of the weight. Today, these composites make up 50% of a commercial aircraft. This innovation has tangible benefits for an aerospace company; reducing the weight of an aircraft by just 2.2 pounds can save between $2,200 and $3,300 per year on operating costs.[117]

> **Computer modeling tools now enable companies to design materials with the exact properties they're seeking.**

AR/VR shines in manufacturing

While many initially wrote them off as just a gimmick, augmented reality (AR) and virtual reality (VR) are proving to vastly increase productivity and efficiency in manufacturing, and more and more businesses are seeing the potential benefits of incorporating them into their processes and products. Gartner predicts that by 2019, 20% of large businesses will use AR, VR, or mixed reality in some way.[118]

20%

Percent of large businesses that will use AR, VR, or mixed reality in some way by 2019.
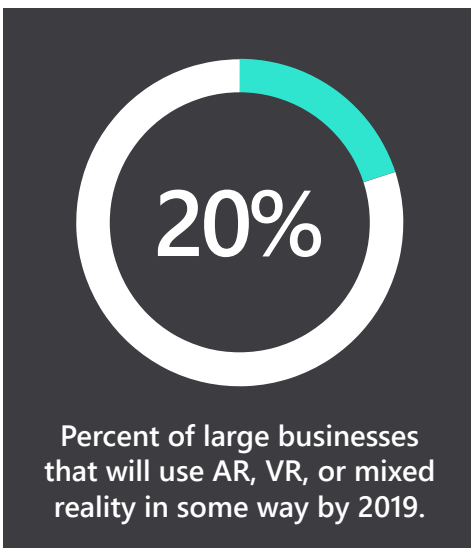
The potential uses for AR and VR in manufacturing may not seem immediately obvious, but they are numer-

ous. It's also important to keep in mind that this is still fairly young technology; as it advances, more uses will become available. Many companies have begun to explore the use of AR headsets that overlay augmented reality onto real objects. Such a device provides the wearer with instant access to a conceivably endless supply of information, helping them complete a task safely and efficiently.[119] Field service engineers at ThyssenKrupp are utilizing Microsoft HoloLens to improve operations and safety. They are able to walk through upcoming jobs, interacting with 3D AR models. On the job, they can use HoloLens to access elevator maintenance history, view 3D replications of parts to identify the problem, receive safety alerts, and even trigger a remote video call to a subject matter expert who can consult on the job. And they can do all of this while keeping their hands free, making them more efficient and safer on the job.

Augmented reality has similar uses when it comes to quality assurance in manufacturing environments. Porsche tested a program in its assembly plant in Leipzig, Germany, where technicians used augmented reality to enhance the QA process. Using AR overlays, technicians compared pictures

Field service engineers at ThyssenKrupp are utilizing Microsoft HoloLens to improve operations and safety.

of parts on vehicles under inspection with those provided by the supplier. The AR tool highlighted features that did not meet specifications, allowing technicians to quickly and easily identify issues. Eventually, Porsche plans to integrate this technology with cameras on the production floor, allowing for real-time analysis of parts and assembly.[120]

Augmented and virtual reality can also be used to quickly and easily facilitate expert assistance. Many manufacturers have distributed operations, and inspectors and technicians need to travel between these physical locations in order to inspect a machine, part, or product. Mixed reality, allows these experts to look through the "eyes" of an on-site technician; they can give advice, troubleshoot, and provide approval from literally anywhere in the world.[121] Clearly, this represents huge potential savings in both time and costs for manufacturers.

Augmented reality also represents a potential solution to the skills gap

in manufacturing. A recent Deloitte study indicated that 3.5 million manufacturing jobs would open up in the next decade in the US—and 2 million of them will go unfilled.[122] The majority of manufacturing jobs now require at least some college education, so sufficiently training a new generation of manufacturing technicians takes more time than it used to. Rather than needing to train every technician to a certain level, companies can utilize AR and VR to provide on-site training and supplement an employee's existing skill set and knowledge with expert help that can be delivered directly to them when needed.[123]

Seemingly small tasks can benefit from augmented reality as well. GE is using facial recognition technology to automatically sign employees into IT systems and resume jobs after a break. This may seem insignificant,

3.5 million manufacturing jobs will open up in the next decade in the U.S.,and 2 million of them will go unfilled.

but it adds up. Previously, employees at GE Healthcare spent almost 100,000 hours a year logging into the IT system. At the same warehouse, workers receiving picklist orders through AR were able to complete the task 46% faster than when using the standard process. These seemingly simple uses of AR technology save companies both time and money.[124]

Innovate and evolve

New technology is changing the way manufacturers design and build products. From digital twins and AR/VR to autonomous vehicles and artificial intelligence, modern manufacturers must leverage the latest technology to deliver innovative products and evolve their businesses. At Microsoft, we're empowering manufacturers with the innovation and tools they need to build the products of the future.

Leverage new tech
Modern manufacturers must leverage the latest technology to stay ahead of the competition. Microsoft provides manufacturers with the innovative technology—like HoloLens—knowledge, and flexibility they need to improve operations, design next-generation products, and deliver amazing product experiences.

Create new products
As the pace of change accelerates, modern manufacturers must always be looking to the future, seeking new trends and innovating new products. Dynamics 365 for Finance and Operations gives manufacturers the data and insights they need to uncover tomorrows trends and the tools and technology to create the products of the future.

Drive innovation
Innovation is the lifeblood of the modern retail business. To innovate, manufacturers must build on an adaptable platform that provides flexibility and scalability. Dynamics 365 enables manufacturers to drive innovation with an intelligent application that is easy to tailor, extend, and connect to other services.

Businesses adapt to an evolving workforce

- Manufacturers plan for an aging workforce
- Millennials become managers and Gen Z graduates
- Diversity and inclusion are at the forefront
- The "no-collar" workforce grows
- Skills gaps create staffing challenges
- Businesses balance technology and politics in corporate offshoring
- New technologies enhance manufacturing safety

Businesses adapt to an evolving workforce

Manufacturers plan for an aging workforce

Older adults (ages 55 and up) are now the fastest-growing segment of the American workforce.[125] As companies shift from pensions towards employee-managed retirement accounts and Americans attempt to rebuild savings wiped out by the 2008 recession, many Boomers are delaying retirement or even returning to work. By the year 2026, older Americans will constitute 26% of the manufacturing workforce, an increase of 12% from 2002.[126]

Leaders in the manufacturing sector are aware of the impact that the aging workforce may have on their businesses in the years to come. In a survey of conducted by the Society for Human Resource Management (SHRM), a majority of manufacturing HR professionals characterized the impending retirement of aging employees over the next two decades as either potentially or definitely problematic for their organization. Eleven percent of HR professionals indicated that the situation would pose a crisis for their company in the next six to ten years; that number jumped to 17% in the 11-20 year range.[127]

In a survey of CEOs of global manufacturing companies, talent was cited as the top driver of market competitiveness.[128] As employees retire, manufacturers are not only confronted with the challenge of filling a growing number open positions, they are faced with the loss of talented individuals who possess both experience and institutional knowledge, exacerbating the sector's widening skills gap. Consequently, a growing number of manufacturing firms are investing efforts to increase training and cross-training, develop succession plans, increase recruiting efforts, and develop processes to capture institutional knowledge to ensure that the next generation of workers is capable of taking the reins when their predecessors step down.[129]

Millennials become managers and Gen Z graduates

Not too long ago, the business world was all aflutter about how to deal with

Executive summary

As Boomers approach retirement and a new, young, highly educated workforce enters the marketplace, businesses are being forced to rethink how they operate.

Highlights

- Older adults (ages 55 and up) are now the fastest-growing segment of the American workforce.

- By the year 2065, there will be no one racial majority in the U.S.

- There could be a need for 736,000 data scientists by 2024, yet estimates only forecast 438,000 data scientists in the workforce.

The workforce is changing.

Projected population by generation *in millions*

	2016	2019	2028	2036	2050
70					
50					
30					
10					

■ Silent ■ Boomer ■ Gen X ■ Millennial
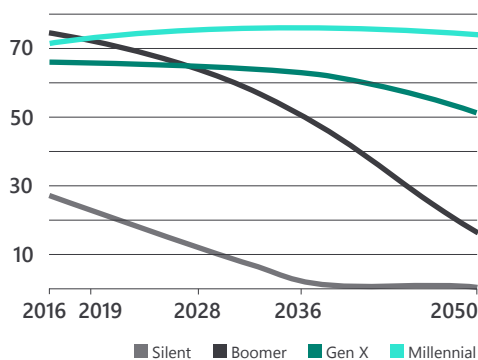
Millennials in the workplace, trying to predict what to expect from this new and seemingly exotic generation. Fast forward to 2018, and the oldest Millennials are already approaching mid-career, with many assuming management roles. And with Millennials taking on higher levels of responsibility earlier in their careers than was common in the past, they are increasingly in the position of managing employees older than themselves.[130]

As a group, Millennials are typically characterized as tech-savvy, entrepreneurial, collaborative, and valuing of work-life balance, and this is impacting their approach to management. In practice, it means that they are likely to embrace the use of workplace communication and collaboration technologies to foster conversation and teamwork and that they promote a flatter hierarchy in the office, embracing good ideas from wherever they originate. And because the current IT environment makes it easier than ever for employees to work whenever and wherever they want, Millennial managers are often more flexible about letting employees take care of personal matters as needed, so long as they stay on top of their work.[131]

Looking to the next generation, the leading edge of Gen Z (also known as iGen) has just begun to enter the workforce. As they do, their beliefs, attitudes, and habits will shape how businesses operate and redefine how managers must lead in order to be successful.

In her book, *iGen: Why Today's Super-Connected Kids are Growing Up Less Rebellious, More Tolerant, Less Happy—and Completely Unprepared for Adulthood*, Professor Jean M. Twenge of San Diego State University analyzes the impact that this genera-tion will have on society as they come of age. Twenge's research revealed that members of Gen Z are both more focused on work compared to Millennials at the same age and more likely to seek stable employment than to be self-employed.[132]

Authors David and Jonah Stillman offer a counterpoint to this perspective in *Gen Z @ Work: How the Next Generation Is Transforming the Workplace*, arguing that this maturing generation's entrepreneurial impulses are simply expressed in a different way. Increasingly, Gen Zers are pursuing interests outside of their full-time employment that also generate income—in today's parlance, everybody's got a side hustle.[133]

Now in their late teens and early twenties, the oldest members of Gen Z grew up during a recession, making them far more risk-averse than Millennials.[134] On average, these digital natives are coming of age later than previous generations, waiting longer to hit seminal milestones like dating, driving, and holding a job. As a consequence, they arrive in the workforce with less life experience under their belts and may require a high degree of oversight and guidance as they adjust to the rhythms and responsibilities of adult careers.[135]

These findings present both opportunities and challenges for companies. From a financial perspective, Gen Z's desire to seek stable, long-term employment could spell higher employee retention rates—and thus lower costs for recruiting and training new employees over time. In exchange, employers must be willing to invest in training and guiding Gen Zers as they adjust to corporate life and as they find ways to direct their entrepreneurial inclinations into their work with the company.

With both generations, companies would be wise to institute formal programs that allow employees to harness their entrepreneurial tendencies for the good of the company—a concept known as intrapreneurship. Companies with intrapreneurial cultures enjoy higher levels of purpose-led management and employee engagement,[136] traits that ultimately lead to creativity, employee loyalty, and innovation.

Diversity and inclusion are at the forefront

Two new generations are poised to take over the workforce; they are both more diverse than previous generations, and they place a higher value on diversity, inclusion, and accessibility than their predecessors. These generations are, of course, Millennials and Gen Z. When compared with Baby Boomers and Gen X, more Millennials and Gen Zers cited diversity and inclusion of a prospective employer as an important factor in their job search.[137]

Research by Nielsen indicates that Gen Z and Millennials, who make up roughly 48% of the U.S. population, are more racially diverse than preceding generations.[138] By the year 2065, there will be no one racial majority in the U.S.[139] The face of the American population is changing, and with it, our expectations of who should be represented in the workplace are changing, as well.

Employees, investors, and the public have begun to demand increased transparency and accountability from companies regarding social issues. In turn, businesses are acknowledging their shortcomings and making commitments and investments to change. Last year was a particularly hard year for the tech industry, with a number of high-profile companies facing intense criticism over missteps and failures with regard to implicit and explicit bias in the workplace.[140]

In response to the growing national conversation around representation and equality, a coalition of corporate executives has banded together to create CEO Action for Diversity & Inclusion, a group dedicated to fostering frank and open discourse about issues like race, gender, and sexual orientation in the workplace. On its website, ceoaction.com, the group has created a repository of best practices for discussing and fostering a more diverse and inclusive workplace.

Public scrutiny aside, there are many reasons companies might seek to have a more diverse workforce—a sense of equity, a desire for a company's employees to more closely resemble the populations they serve,[141] and even profitability. Research by McKinseyshows that co mpanies in the top quartile of gender and racial diversity were more likely to deliver financial returns that were above their national industry median than those less diverse.[142] And according to "Women in Manufacturing 2017," a report by Deloitte, the Manufacturing Institute, and the American Production and Inventory Control Society, placing a stronger emphasis on recruiting women (who currently only account or 29% of the manufacturing workforce) may be critical to addressing the growing skills gap in the manufacturing sector.[143]

As companies embrace gender and racial diversity, they open themselves up to a diversity of ideas that can uncover new opportunities, challenge long-held assumptions, and help unlock new communities of talented individuals.

29%

Women currently only account for 29% of the manufacturing workforce.

Rockwell Automation was the Windows 10 IoT Enterprise operating system to design a hybrid automation controller that easily connects to customers' IT environments and Azure IoT Suite, giving them immediate access to data at the point of operation.

The "no-collar" workforce grows

As manufacturing becomes an increasingly technical craft, manufacturing jobs will cease to be defined by manual labor. Instead, the future of manufacturing will be characterized by skilled laborers whose efforts are augmented by technology—and with it, the rise of the no-collar workforce.

With the introduction of robotic process automation, AI, computer vision, and other smart technologies in the workplace, companies are redefining how work is done in a manufacturing setting. By identifying and automating processes that can be completed by machines, companies can improve efficiency and reduce errors while also freeing up their employees to focus on high-value tasks that require a human touch. Employers are taking advantage of this revolution in intelligent automation to retrain employees on the use of new technologies[144] and empowering them to make decisions based on real-time data.[145]

One company that is revolutionizing how the no-collar workforce operates is Rockwell Automation, which is using Microsoft products to give manufacturing customers real-time insight into their operations. The company uses the Windows 10 IoT Enterprise operating system to design a hybrid automation controller that easily connects to customers' IT environments and Azure IoT Suite, giving them immediate access to data at the point of operation. These insights allow managers to make changes mid-shift (instead of after operations cease) and reduces decision-making time from hours to milliseconds.[146]

Skills gaps create staffing challenges

As a result of the industry's shift from blue collar to no-collar jobs, companies are struggling to find workers with the skills necessary to meet today's advanced manufacturing requirements. A study conducted by Deloitte on behalf of the Manufacturing Institute reveals startling insights about the growing skills gap in the manufacturing industry.
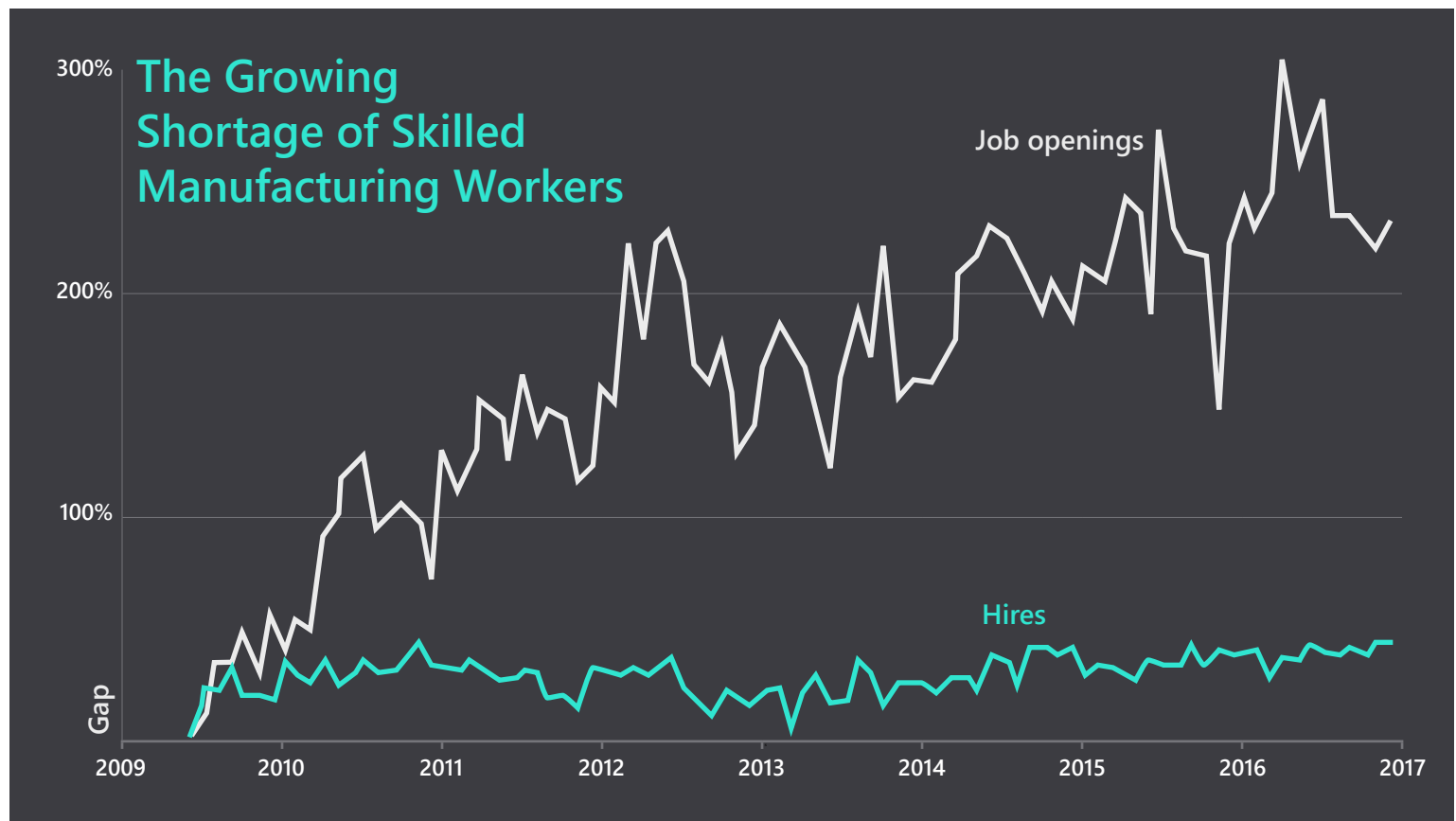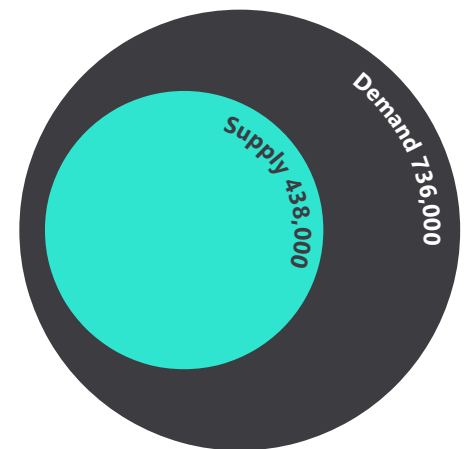
Over the next decade, employers will seek to place talent in nearly 3.4 million manufacturing jobs (2.7 million to replace the existing workforce as Baby Boomers retire and the remaining 700,000 new jobs due to anticipated economic expansion). However, because of the skills gap, it is likely that 2 million of these jobs will remain unfilled. At present, fully 60% of open production positions are unfilled because of a talent shortage. The number of positions left open due to the skills gap is growing; over the next decade, nearly 2 million manufacturing jobs will go unfilled.[147]

Eighty-two percent of executives worry that the skills gap will negatively influence their ability to meet customer demand. A majority of executives also worry about the impacts the skills gap will have on productivity and innovation, the ability to implement new technologies, and customer service.[148]

Both government and private industry are looking at ways to close the skills gap. For example, the National Network for Manufacturing Innovation, which was formed in 2014 by a group of federal agencies and manufacturers, focuses on providing workers with skills and training relevant to 3D-printing and digital manufacturing. Other interventions seek to improve access to training for both adults and high school students before they enter the workplace.[149]

Supply and demand of data scientists by 2024

Demand 736,000

Supply 438,000

The Growing Shortage of Skilled Manufacturing Workers

Job openings

Hires

Gap

What exactly do employees need to bring to the table in order to be successful in today's manufacturing climate? Employers say the skills gap boils down to insufficient training in math, problem-solving, basic technical training, and technology and computer skills.[150] Any effective long-term solutions will have to address how we as a society approach vocational training and view the manufacturing industry. For their part, manufacturers should embrace a two-pronged approach. First, companies can address the existing skills gap by providing training to help employees develop the skills they need. Second, companies must begin actively recruiting engineering and computer science students at colleges and universities, as they are likely unaware of the rigor and opportunities for growth afforded by a career in manufacturing.

Businesses balance technology and politics in corporate offshoring

Since the turn of the millennium, there has been a steady growth in offshoring, driven largely by improved communication (via technology), easier travel, and a growing low-cost, high-skilled labor market abroad. But the same disruptive force that enabled companies to move jobs overseas—technology—may now be responsible for bringing them back onshore.

The adoption of robotic process automation, artificial intelligence, and machine learning is allowing companies to automate routine jobs that previously would have been outsourced to a human workforce overseas. This trend has resulted in a resurgence of domestic jobs, as companies hire skilled professionals to oversee and troubleshoot technology in onshore facilities while continuing to invest in research to advance developments in these fields.[151] For manufacturing companies, the decision to bring low-skill tasks back in-house while simultaneously generating new, high-skilled positions is one that can potentially reap cost savings as well as political goodwill.

While technology is enabling companies to reduce offshore commitments, recent developments in domestic and international politics may be having the opposite effect. In the U.S., a newly introduced tariff on steel and aluminum may force companies to offshore the purchase or manufacturing of certain goods. At present, the domestic demand for steel and aluminum outstrips the available supply. Because of the tariff—which affects raw materials but not finished products—companies that manufacture products on U.S. soil using imported steel may no longer be able to afford to do so, and in some cases, may opt to offshore their manufacturing. Likewise, companies that currently source steel components from U.S. companies may choose to import finished products from manufacturers overseas in order to remain price competitive.[152]

The Tax Cut and Jobs Act, which was signed into law last December, may also have unintended effects on offshoring by U.S. businesses. The plan institutes the creation of a territorial tax system, under which profits earned by U.S. companies in foreign countries are not subject to U.S. taxes. Many experts fear that this will incentivize businesses to move jobs and operations to countries with lower tax rates than can be found domestically.[153]

And in Europe, Britain's decision to exit the E.U. could result in jobs flowing out of the U.K. Due to uncertainty about the domestic job market and to the high cost of hiring foreign employees as a result of Brexit, skilled jobs which were previously filled by citizens of other E.U. member countries who had relocated to the U.K. for work may end up being outsourced outside Britain's borders.[154]

The same disruptive force that enabled companies to move jobs overseas—technology—may now be responsible for bringing them back onshore.

New technologies enhance manufacturing safety

Although the manufacturing industry is considerably safer than it was in the days of the Industrial Revolution, workplace injuries are still a risk for present-day manufacturing professionals. Thankfully, advances in AI, computer vision, IoT, and facial recognition are helping businesses become safer than ever.

With Computer Vision from Microsoft Cognitive Services, Prism Skylabs is revolutionizing the way that companies use video. Their new app, Prism Vision, allows customers to access, view, summarize, and search video from any camera in their network. Prism Vision's AI and machine learning capabilities open up a range possibilities for customers: managers can use the app to ensure that employees are following proper safety protocols, identify problems on the line that could result in injury and adjust production accordingly, and flag incidents like spills before they cause harm.

Boeing is another manufacturer that is successfully harnessing technology to make the workplace safer. For years, the company has partnered with Zebra to enhance the safety of its painters. Using Zebra's MotionWorks™ an Ultra Wide Band real-time locating system, Boeing is able to monitor the location and status of its painters while they are using aerial equipment, ensuring that they are following safety protocols and that their harnesses are in proper working order.[155]

Likewise, advances in facial recognition are helping companies maintain perimeter security at their facilities, ensuring that only authorized personnel are granted access. As these technologies continue to advance, expect to see pioneers in manufacturing applying them in new, innovative ways to make the workplace even safer and more efficient.

Transform for the future

Two new generations of socially-minded, tech-savvy individuals are changing the workplace. As this evolving and empowered workforce seeks to leave their mark on their world, manufacturing leaders must empower them with the vision, opportunity, and resources to do so. As we undergo our own cultural transformation at Microsoft, it informs and inspires our pursuit to empower our clients as they transform their organizations for the future.

Empower employees

Employees are a business's most valuable asset; today's organizations must empower their employees to do more. From tools like Office 365 that help teams get more done to role-based workspaces in Dynamics 365 that put the right information at each employee's fingertips, Microsoft is helping businesses empower their employees to change the world.

Make tech accessible

Successful business leaders are seeking diverse perspectives and new ideas to challenge their most ingrained assumptions. With intuitive, familiar tools that are easy to learn and cloud-based applications that allow individuals to access information from anywhere, Microsoft is making technology more accessible to more people than ever before, opening up untapped markets for talent and innovation.

Transform culture

As our world faces new challenges, manufacturers must transform their cultures to posture their workforce to solve today's most pressing problems. From tools that improve communication across an enterprise to the platform on which a startup will build the app that will disrupt an industry, Microsoft is empowering businesses to redefine their culture.

Living in the age of uncertainty

- Regulation changes create uncertainty
- GDPR is here
- Businesses brace for Brexit
- Leaders try to navigate a highly politicized environment
- Industries converge
- The global manufacturing industry is thriving despite pervasive uncertainty

Living in the age of uncertainty

Regulation changes create uncertainty

Over the last 18 months, a string of major regulatory changes has been initiated and enacted. From GDPR to tariffs, these regulations span across a wide range of disciplines and touch nearly every business. As business leaders adapt to comply with the latest regulations, they remain concerned over the impact of additional pending regulations that could upend their operations. In 2018, 42% of CEOs globally and 50% of CEOs in North America reported over-regulation as a top concern,[156] with 54% citing rising risk levels due to industry-specific regulation.[157]

Manufacturing regulation

From rollbacks in worker safety rules and emissions policies to net neutrality, tariffs, and subsidies, manufacturers across all industries are facing a great deal of regulatory uncertainty and flux. While we are currently in a period of regulatory easing, longer-term macro-trends suggest movement towards higher labor and environmental standards.

As such, manufacturers must not only grapple with the operational and financial impact of these changing regulations; they must also weigh the impact of these changes on other areas of their business as they develop both their short- and long-term strategies. These include the effects of lower worker safety standards on talent retention and healthcare costs and customer perceptions of products that are environmentally damaging.

Data protection

Data protection and data privacy compliance are huge concerns for today's business leaders, with 78% expressing increasing concerns in a recent study by EY.[158] As many companies struggle with managing and securing their customers' data, regulators are now making moves to empower consumers and ensure the privacy of this data.

As GDPR rolls out in the European Union (E.U.), it's impacting businesses worldwide, affecting any business who has customers in the E.U., and many companies

Executive summary

In an incredibly polarized political environment, attitudes can shift on a dime, making it difficult for companies to plan for the future.

Highlights

- Forty-nine percent of business leaders feel that they are exposed to more uncertainty today than they were three years ago.

- Forty-two percent of global CEOs reported over-regulation as a top concern.

- Sixty-six percent of consumers felt it was important for brands to take a public stand on social and political issues.

> **Forty-two percent of global CEOs reported over-regulation as a top concern.**

9%

Percent of U.S. companies who said they felt well informed about the GDPR.

remain unprepared. In an early 2018 study, only 33% of companies reported having a plan while 39% said they were not familiar with GDPR at all.[159]

As businesses try to manage GDPR, many are also facing the prospect of new regulations as the U.S. grapples with several large data breach cases, each with far-reaching consequences, and weighs options for better managing data privacy and consumer protections.

Trade policy

With newly imposed tariffs on imported steel (25%), aluminum (10%) and solar panels (30%), many business leaders and financial experts fear that new trade tariffs could negatively affect domestic economic growth and accordingly, hurt job growth.[160] There is also increasing concern regarding the potential for future tariffs. Sparked by these new tariffs, and the list of 1,300 additional tariffs that have been proposed by the U.S., nearly three-quarters of business leaders are now worried about a trade war,[161] which could have an extremely negative impact on businesses in the U.S. and abroad.

Other policies

Beyond manufacturing, privacy, and trade, there is a long list of policy areas currently being upended that are of great interest and concern to manufacturers. From immigration to labor policy, new legislation is impacting how businesses source and manage talent and has the capacity to impact businesses across the supply chain. Many industries are also being impacted by rollbacks in environmental policies, which can affect sourcing and operations. Some industries, like the technology industry, have been relatively unified in their objection to these environmental policy changes,[162] while others, like utilities, remain divided.[163]

Beyond regulatory policy, many other policy uncertainties exist on the horizon, including international policy in regions like North Korea, Syria, Yemen, and Iran, each of which could have a substantial impact on businesses and the world.

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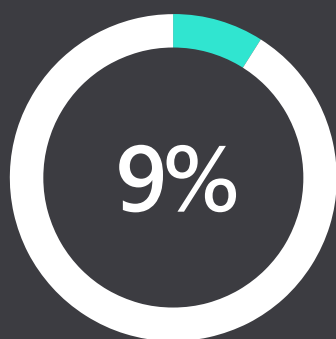
GDPR is here

On May 25, 2018, a European privacy law took effect and set a new global bar for privacy rights, security, and compliance. The General Data Protection Regulation (GDPR) is fundamentally about protecting and enabling the privacy rights of individuals. The GDPR establishes strict global privacy requirements governing how businesses manage and protect personal data while respecting individual choice—no matter where data is sent, processed, or stored.

The GDPR imposes new rules on organizations that offer goods and services to people in the E.U., or that collect and analyze data tied to E.U. residents, regardless of where the business is located. Among the key elements of the GDPR are:

Enhanced personal privacy rights
Strengthening data protection for individuals within the E.U. by ensuring they have the right to access their data, to correct inaccuracies, to erase data, to object to the processing of their information, and to move their data;

Increased duty for protecting data
Reinforcing accountability of companies and public organizations that process personal data, providing increased clarity of responsibility in ensuring compliance;

Mandatory data breach reporting
Requiring companies to report data breaches to their supervisory authorities without undue delay, and generally no later than 72 hours; and

Significant penalties for non-compliance
Imposing steep sanctions, including substantial fines, that are applicable whether an organization has intentionally or inadvertently failed to comply.

Even with the law now in effect, there are still many questions surrounding the GDPR, and many businesses are still under-informed about the new regulation. Only 36% of IT professionals in the E.U. and 9% in the U.S. said they felt well informed about the GDPR and its impact on their business.[164] As of mid-2017, only 28% of E.U. businesses and 5% of U.S. businesses reported that they had already started preparations to comply with the new laws. And as companies roll out plans, many concerns remain about ambiguity in the requirements, which could cost businesses millions if they fail to comply.

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GDPR compliance readiness
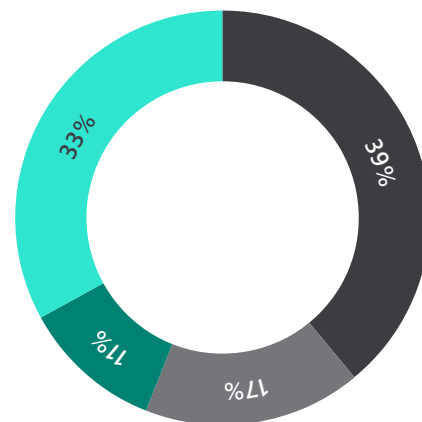
- I'm not familiar with the GDPR
- We have heard of the GDP but have not yet taken any action
- We are studying the GDPR and its scope
- We have a plan for GDPR

Businesses brace for Brexit

On June 23, 2016, Britain shocked the world when they passed a referendum to leave the European Union (E.U.). This decision sent a shockwave through global markets as the implications of Britain's departure from the European Union moved from theory to reality.

The initial vote was met with severe backlash from the business world. The British Pound plunged and has remained roughly 15% lower compared to the dollar than before the referendum.[165] While the FTSE 100 has recovered from its initial fall,[166] a long list of outstanding Brexit unknowns have resulted in a choppy start to 2018,[167] and the uncertainty has pushed U.K. government bonds to record lows as investors seek safer assets.

Many U.S. businesses are now having to make difficult decisions about how to proceed with business in the U.K. For many, the U.K. was a link into the E.U., but with the U.K. now leaving the E.U., many are reconsidering their U.K. operations. In one study by Gowling WLG, two-thirds of U.S. businesses polled said that the Brexit decision was already impacting investment choices in the county.[168] Half of the businesses polled cited plans to bypass the U.K. in order to do business directly with the E.U.

The sheer uncertainty surrounding Brexit is also having an impact on the job market in the U.K., with companies, job seekers, and employees all showing signs of cold feet. In the year following the Brexit vote, fewer foreigners applied for work in the U.K., uncertain about their ability to stay and work, and fewer British companies sent offers to job seekers located outside the U.K. This has caused the representation of foreign candidates in the U.K. talent pool to decrease by 50%.[169] In addition, 41% of U.K. tech workers surveyed said they were less likely to start their business in the U.K. due to Brexit.

As the Brexit date approaches, businesses are still seeking clarity from the U.K. government on future trade arrangements with the E.U. and the world. This ambiguity has created a great deal of frustration for business leaders, who are struggling to set long-term investment strategies as a result of the uncertainty.

The U.K. is scheduled to leave the E.U. on March 29, 2019.

The U.K. is scheduled to leave the E.U. on March 29, 2019.

British Pound/U.S. Dollar
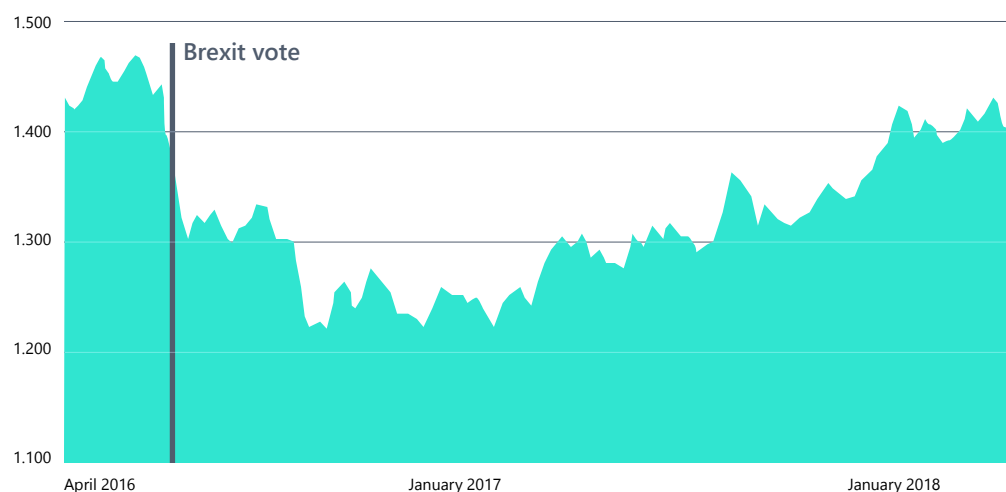
Legal note: The material contained within this document is for informational purposes only and is not meant to be a substitute for professional advice. Please consult an accounting or legal professional for advice on any new rules and guidelines.

Sixty-six percent of consumers feel it is important for brands to take a public stand on social and political issues.

Leaders try to navigate a highly politicized environment

While companies have historically taken a highly strategic and tactful approach to public relations, massive social media campaigns and boycotts—like #GrabYourWallet, a movement started by Shannon Coulter in October 2016—have forced many companies to enter the political conversation, whether they wanted to or not.

Executive orders directly affecting both customers and employees have prompted companies to take a political position, with CEOs from Microsoft, Apple, Google, Goldman Sachs, Starbucks, Nike, Tesla, and Facebook (among many others) decrying certain policies—including those on immigration and the environment—in public statements and pledging to protect their employees who might be impacted by particular decisions.[170] An executive order in April 2017 calling for a review of national monuments prompted outdoor retailers REI, Patagonia, and The North Face to urge customers to contact their legislators and oppose any legislation that threatens federally protected public land.[171]

In the past, it was rare for large companies to make openly political statements; however, with changing demographics, the rise of social media, and a rapidly shifting political environment, customers are vocal when they believe a business has misstepped and now expect brands to take a stand on issues. In a recent study by Sprout Social, 66% of consumers felt it was important for brands to take a public stand on social and political issues.[172]

> **Forty-seven percent of executives are preparing their companies for an influx of entrants from other sectors.**
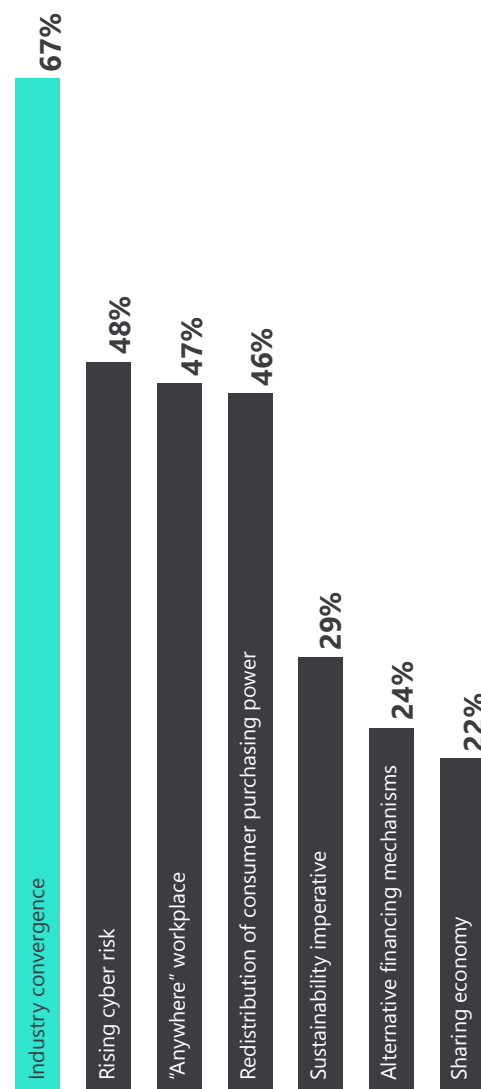
The single biggest trend business leaders think will transform the business arena

Industries converge

As organsnizatio invest in technology and transform their companies through new business models, the boundaries of how a company may leverage their technology are becoming increasingly blurred. You don't have to look far to find examples of technology companies transcending industries to invest in autonomous vehicles, healthcare technology, brick and mortar retail, and entertainment. In a sense, as all companies become technology companies, the reciprocal also becomes true: a technology company can be any type of company.

In IBM's Global C-suite Study, industry convergence was the biggest trend business leaders saw transforming the business landscape. Accordingly, 47% were preparing their companies for an influx of entrants from other sectors, a 27% increase from 2013.

In today's fast-moving business world, companies will continue to face more competition and new challenges. And as they do, they will continue to rely on their leaders to navigate through uncertainty towards growth and progress.

	%
Industry convergence	67%
Rising cyber risk	48%
"Anywhere" workplace	47%
Redistribution of consumer purchasing power	46%
Sustainability imperative	29%
Alternative financing mechanisms	24%
Sharing economy	22%

The global manufacturing industry is thriving despite pervasive uncertainty

Recent events in U.S. and U.K. politics have upended existing relationships between nations, leading many to worry about the potential fallout for global trade and commerce. Despite these concerns, global manufacturing output remains robust.

Business leaders are trained to "expect the unexpected," but living in limbo can take a toll, and long-term uncertainty—whether geopolitical, regulatory, social, or other—has been associated with prolonged declines in economic activity.[173] More concerning, research also shows no evidence of a rapid rebound when uncertainty declines—known as the "wait-and-see" effect. Instead, the data show that uncertainty exists in a series of feedback loops which signal bad economic times.

In the NBER paper, "Uncertainty and Economic Activity," researchers Bachmann, Elstner, and Sims show that in an uncertain environment, businesses shift to a defensive posture. Due to uncertainty, businesses reduce overall investment, which leads to a decrease in hiring, work hours, research and development, manufacturing production, and labor productivity. Bachmann, Elstner, and Sims write that, "Business uncertainty [has] effects similar to negative business confidence," and go on to detail how during these cycles, hard-earned relationships are damaged and business models fail. All of this, in turn, cuts economic output and drives further uncertainty, which restarts the cycle. "Business and customer relationships have to be re-established and business models altered when the economy is at trough. This generates uncertainty." Summarized succinctly in their final words, "Uncertainty is a concomitant phenomenon of negative first moments events in the economy. Bad times breed uncertainty."

From Brexit negotiations and trade tariffs to immigration reform and environmental policies, the unpredictability of today's political and social landscape should have a dampening effect on the manufacturing sector. And yet, performance data from 2017 and 2018 indicate that this is not the case.

According to a report from the manufacturing industry group EEF, growth of the manufacturing sector in the Western world outpaced growth of the economy as a whole during 2017, with England's manufacturing industry experiencing nine months of uninterrupted growth and expanding an impressive 2.8%.[174] Similarly, the Purchasing Manager's Index—an indicator which is based on new orders, inventory levels, production, supplier deliveries and the employment environment—remains above 50 in the U.S. (56.5), England (55.1), and the Eurozone (56.6), indicating expansion of the sector.[175][176] According to the World Bank, this growth was driven in large part by the activity of commodity exporters and by gains in productivity due to automation.[177] IHS Markit also attributes growth in the U.S. to new client acquisitions and to the growth in export orders, despite price increases caused by the introduction of new tariffs and by the rising cost of raw materials.[178]

The full implications of recent developments in global politics have yet to be understood. Even so, early indications show that the manufacturing sector remains resilient in the face of uncertainty.

Pivot and adapt

Today's business leaders face many difficult decisions as they navigate through a time of considerable ambiguity and uncertainty. At Microsoft, we're empowering these leaders with greater visibility into their business operations and performance to help them identify emerging hazards and with the flexibility to adapt quickly and scale with ease.

Better manage risk

From cybersecurity to compliance, manufacturers must address a wide range of threats to their business. With Azure's security, privacy, transparency, and industry-leading compliance coverage, business leaders can better manage cyber risks, and with unified data in the cloud, manufacturing teams can improve reporting speed and accuracy.

Increase flexibility

To succeed in a world of uncertainty, manufacturers must be flexible to quickly pivot and adapt as market conditions change. With Azure and Dynamics 365, organizations have the flexibility to deploy how and where they want, leverage extensions to quickly add new, customizable capabilities, and easily manage how system updates and new features are implemented across the organization.

Scale with ease

Manufacturers face many challenges as they look to scale at home, abroad, and into new verticals. Dynamics 365's cloud deployment options make scaling easier than ever, whether a company is looking to scale up or down to better manage seasonal demands or duplicate a Dynamics 365 instance on a server in a new country they're entering.

Conclusion

The world is changing and as a result, so is manufacturing. In addition to the trends covered in this report, many other changes, challenges, and new technologies are impacting manufacturing, including value chain execution efficiency demands, security challenges, smart sensors, wearables, SMAC-stack, and risk management. As manufacturing companies of the past turn into the advanced manufacturing businesses of the future, industry leaders must leverage technology to help bridge the gap, improve safety and operations, provide greater transparency, and deliver better products and experiences.

Accelerate your business growth.

Digital transformation
Modern businesses must embrace digital transformation to create value for their customers, empower employees, optimize operations, and transform products.

Dynamics 365
Microsoft Dynamics 365's suite of holistic, connected applications enables businesses to power intelligent business processes through digital feedback loops.

Finance and Operations
Microsoft Dynamics 365 for Finance and Operations gives businesses the tools to empower their people to make smarter decisions, transform processes, and drive rapid growth.

Digital transformation

Technology is disrupting every industry. Today, rapid transformation is the status quo and competition arises from everywhere. From manufacturing, financial services, and retail to healthcare, education, and government, business leaders are trying to understand what this change means for their organizations and how they can digitally transform to prepare for the future.
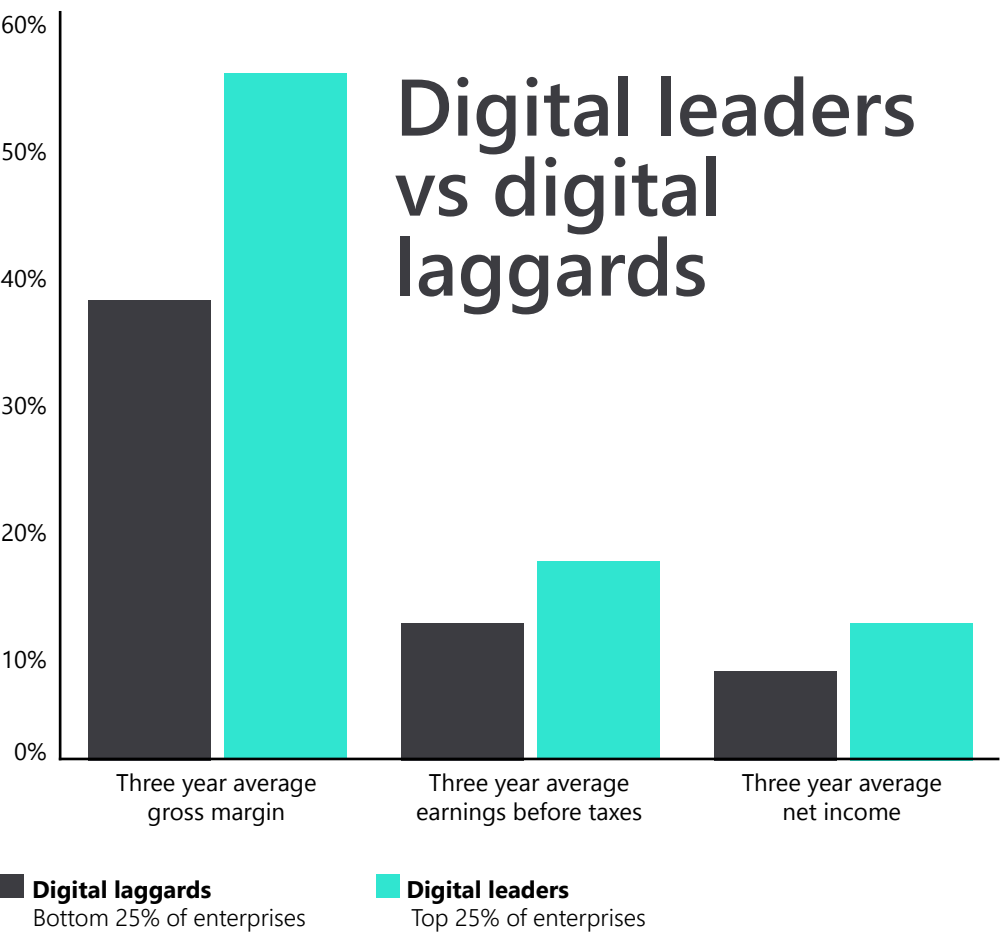
For companies to survive and thrive in this new era, they must embrace digital transformation. But digital transformation is not simply about technology; it requires a culture shift and new processes. It demands that business leaders evaluate and reimagine their existing business models. Organizations must embrace a different way of bringing together people, data, and operations to create value for their customers, empower employees, and transform products. They must leverage every device, system, process, and asset across the company to turn data into action and create systems of intelligence.

Microsoft is in a unique position in that we are not only able to support our customers through their entire journey of transformation, but we can also solve for the many other challenges that come with managing and optimizing disparate, siloed solutions with:

- Modern Business Process with **Dynamics 365, Power BI, PowerApps and Flow**
- Complete Cloud Provider with **Azure and Intelligence/AI**
- Empowered worker productivity with **Microsoft 365**

The customer benefits of working with a single provider include having only one vendor to manage, one identity solution that is integrated, one document storage solution that can be accessed from anywhere, one productivity solution that leverages familiar usability across apps, and most importantly, one common data platform.

Digital leaders vs digital laggards

Digital laggards
Bottom 25% of enterprises

Digital leaders
Top 25% of enterprises

Three year average gross margin · Three year average earnings before taxes · Three year average net income

Customer benefits:

1. One productivity solution
2. One intelligence solution
3. One 'citizen developer' solution
4. One document storage solution
5. One identity solution
6. One cloud
7. One vendor
8. One support contract
9. One solution marketplace
10. One common data platform

"The Digital Business Divide, Analyzing the operating impact of digital transformation;" Marco Iansiti, Karim Lakhani, January 2017.

At Microsoft, our mission is to empower every person and every organization on the planet to achieve more. Our strategy is to build best-in-class platforms and productivity services for a mobile-first, cloud-first world.

Microsoft Dynamics 365

As organizations look to digitally transform and create systems of intelligence, they are shifting away from traditional, monolithic ERP systems that are difficult to implement and maintain and moving towards modular, modern platforms, such as Dynamics 365, that allow them to intelligently and flexibly manage their business.

Dynamics 365 is empowering businesses to drive true digital transformation through a suite of holistic, connected applications, and through the Microsoft cloud, Dynamics 365 can integrate with LinkedIn, Microsoft 365, Azure, and all of the other assets that we've built.

Unifying data from across the organization enables businesses to power intelligent business processes through digital feedback loops and deliver experiences that are synergistic and seamless.

Digital feedback loops

When businesses leverage business application platforms such as Dynamics 365 to create systems of intelligence within their organizations, it creates a digital feedback loop where data informs and creates action. This new action, in turn, creates more data, which informs further actions. This interplay between insight and action creates a digital feedback loop that powers a cycle of continuous improvement.

These digital feedback loops are powered by data, which is one of the biggest drivers of digital transformation, and we can now extract data from anything and everything. Every time someone tweets, visits a website, walks into a store, and every time they use a connected product, there's data flowing from that interaction from which we can gain insights and take action.

Beyond a feedback loop in a stand-alone system, businesses can unify data from separate, but related, systems, allowing inputs from one loop to inform another, powering intelligent business processes.

As businesses digitally transform, these intelligent business processes will benefit from the unification of four key areas: customers, products, operations, and people.

Customers
When leveraged correctly, customer data can help businesses gain a deep understanding of their target market's wants, needs, interests, and intent, enabling brands to engage with their customers more intelligently than ever before.

Products
Usage data can inform companies of how their products and services are being used, allowing them to optimize their current offerings and develop new offerings to meet market demands.

Operations
By gathering data from across the supply chain, businesses can optimize their operations, better forecast demand, and manage inventory through automated ordering and distribution.

People
Modern businesses need talented people who can embrace digital technologies, understand data, and interact with customers and connected products in a way that wasn't possible before. Recruiting and developing these individuals is a requirement to be successful in this transformed economy.
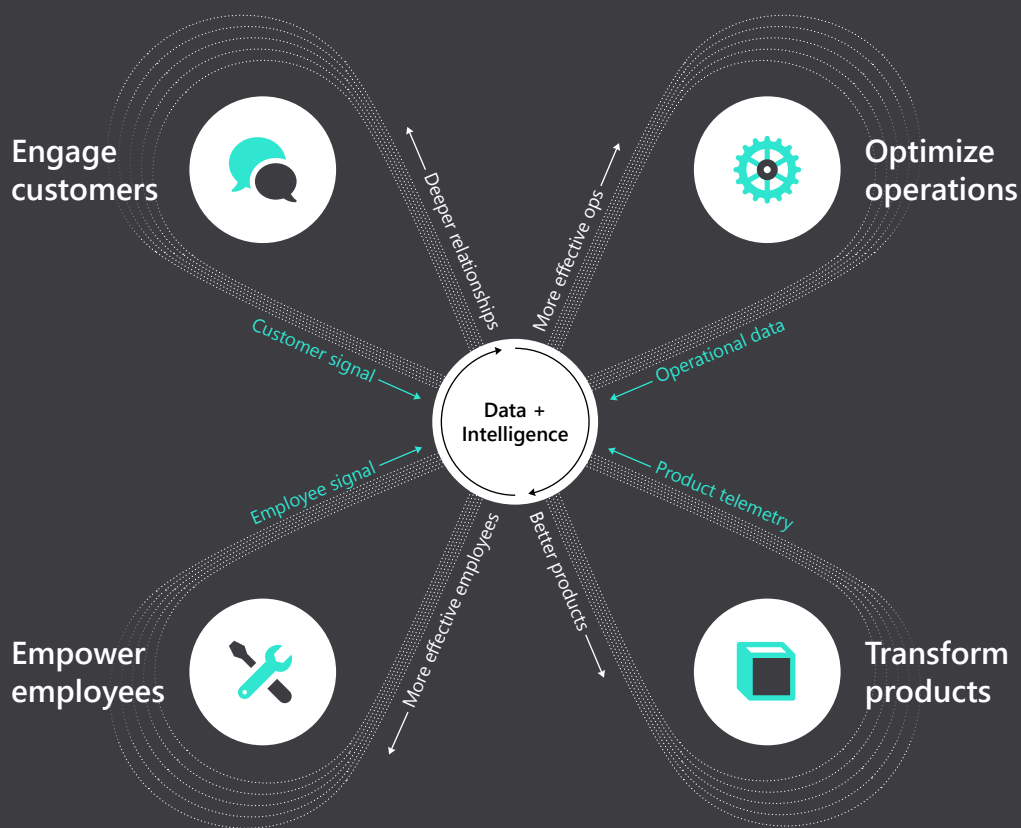
Digital feedback loops

1 Data
Data is captured as a digital signal across the business.

2 Insight
Intelligence is applied to connect and synthesize the data.

3 Action
Action is recommended and taken to improve business outcomes.

Engage customers

Optimize operations

Empower employees

Transform products

Data + Intelligence

Deeper relationships
More effective ops
Customer signal
Operational data
Employee signal
Product telemetry
More effective employees
Better products

As organizations look to digitally transform their businesses to deliver amazing customer experiences, design innovative products, and empower their people, they require modular, modern platforms—like Dynamics 365—so they can more intelligently and flexibly manage their business and unlock new opportunities to grow their bottom line.

Dynamics 365 lives up to its name by powering organizations with solutions that are modern, unified, intelligent, and adaptable.

Modern
Dynamics 365 solves specific business problems with modern, multi-channel mobile applications that work seamlessly together—and with your existing systems.

Unified
Dynamics 365 creates a more significant impact by unifying relationships, processes, and data across applications and ecosystems—powered by Microsoft Cloud with Microsoft 365, LinkedIn, and Azure.

Intelligent
Dynamics 365 delivers actionable insights and predictive outcomes with infused intelligence, built on Microsoft's leading artificial intelligence and analytics technologies.

Adaptable
Dynamics 365 adapts processes to unique business needs in real time by connecting, extending, and building applications on a platform that's flexible, scalable, and secure.

We're empowering organizations with intelligent end-to-end applications that perform well on their own and even better together across Sales, Marketing, Customer Service, Field Service, Retail, and Talent.

For businesses looking to deliver true digital transformation across their organization, Finance and Operations gives businesses the tools to accelerate the speed of doing business by empowering people to make smarter decisions, transform business processes faster, and drive rapid business growth.

Microsoft Dynamics 365
Modern business applications

- Marketing
- Sales
- Customer Service
- Field Service
- Project Service Automation
- **Finance and Operations**
- Talent
- Retail

Finance and Operations

Microsoft Dynamics 365 for Finance and Operations is Microsoft's back-office business application, built on and for the Microsoft Azure cloud. It unifies financials and business operations across finance, manufacturing, supply chain, warehouse, inventory, and transportation management with an intelligent and intuitive user interface for running game-changing, modern global enterprises. And it provides organizations with a service that can support their unique requirements and rapidly adjust to changing business environments without the hassle of managing infrastructure.

Dynamics 365 for Finance and Operations brings together a set of adaptable ERP capabilities, BI, infrastructure, compute, and database services in a single offering that enables organizations to run industry-specific operational business processes that are extendable with specific solutions from business partners. Organizations can match their business growth by easily adding users and business processes with a 'pay-as-you-go' model.

Designed to accelerate the speed of doing business, Microsoft Dynamics 365 for Finance and Operations helps people make smarter decisions with an intelligent and intuitive user interface. It transforms business processes faster with proven methodologies, best practices, and enables organizations to do business nearly anywhere, anytime, on any device with the choice and flexibility of the cloud.

Dynamics 365 for

Finance and Operations

Discover how Microsoft is helping customers accelerate the speed of doing business by empowering people to make smarter decisions, transform business processes faster, and drive rapid business growth.

Enhance digital factories
Boost productivity by modernizing the workplace with automation and AI.
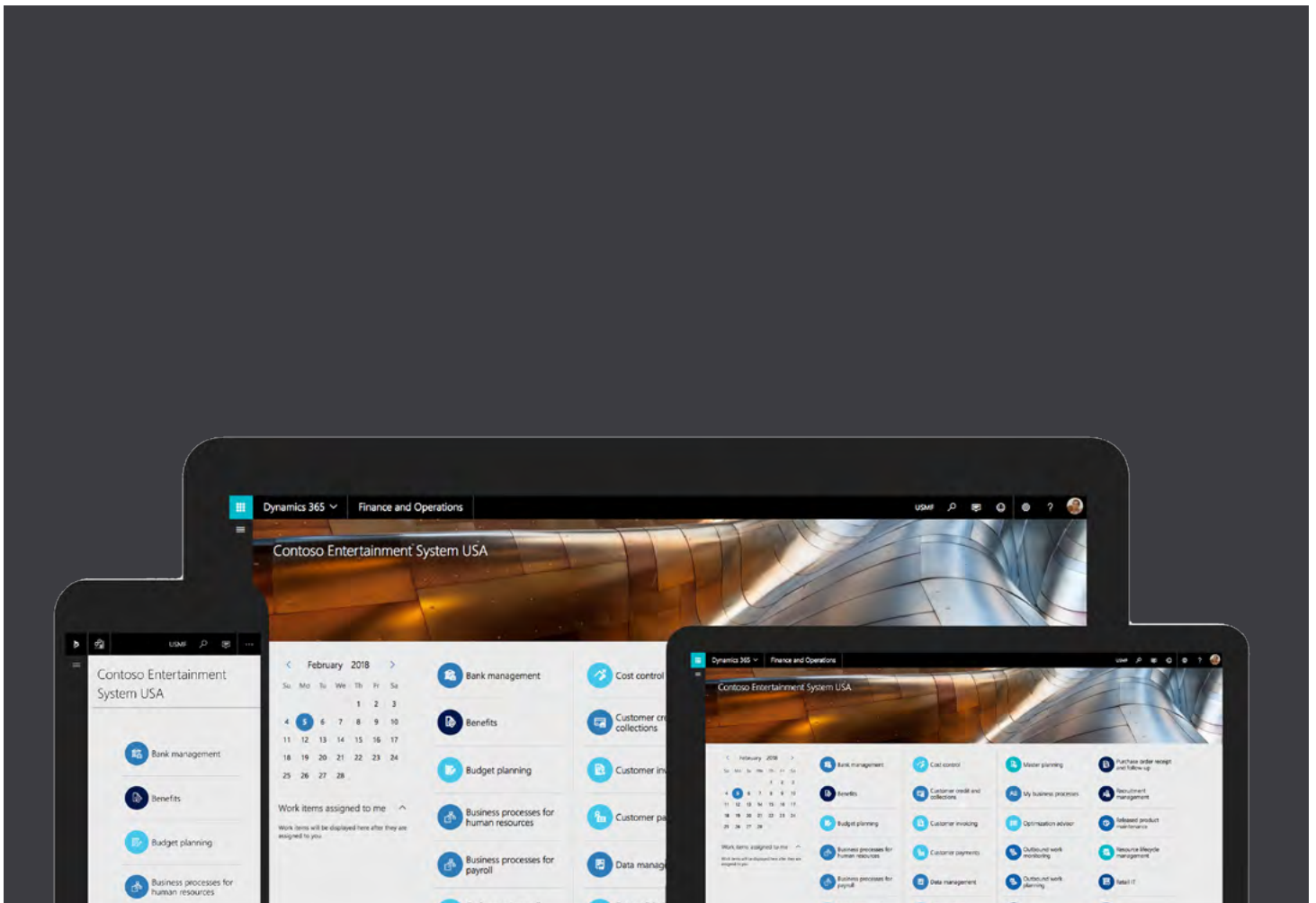
Monetize connected products
Increase margins from digital products and services with intelligent business apps.

Create intelligent value chains
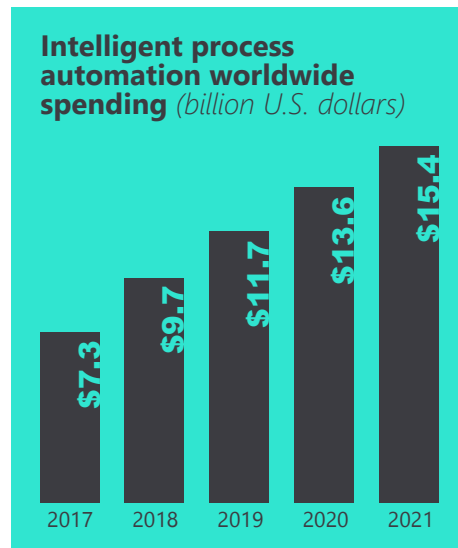Open new markets with secure and intelligent edge and cloud.

Enhance digital factories *Boost productivity by modernizing the workplace with automation and AI.*

Today's manufacturers are actively driving towards the factory of the future. With vast stores of data generated by supply chain operations, plant-floor systems, connected products, and customer-facing activities, achieving visibility is a huge challenge. Microsoft enables you to create an intelligent workplace by arming workers with real-time insights, optimizing processes using digital twins, and augmenting employee skills with AI, mixed-reality interaction models, robots, and cobots.

With intuitive, familiar tools, Dynamics 365 for Finance and Operations augments employees skills and gives them the information they need to make faster decisions and increase productivity on the factory floor.

By connecting assets across sites in the cloud, manufacturers are able to gain greater visibility into operations

Intelligent process automation worldwide spending *(billion U.S. dollars)*

2017	2018	2019	2020	2021
$7.3	$9.7	$11.7	$13.6	$15.4

and derive insights that can help improve performance and productivity. These real-time insights can also help detect defects and resolve issues with limited impact on production. And by modeling new production processes, manufacturers can develop factory designs that maximize efficiency and sustainability.

Enhance digital factories

Increase productivity on the factory floor

Give employees an intelligent workplace that mirrors the technology-rich environment today's consumers experience at home.

Leverage insights to drive operational excellence

Connect assets across manufacturing sites to predict and address inefficiencies, improve performance, and reduce the time and expense of costly equipment failures.
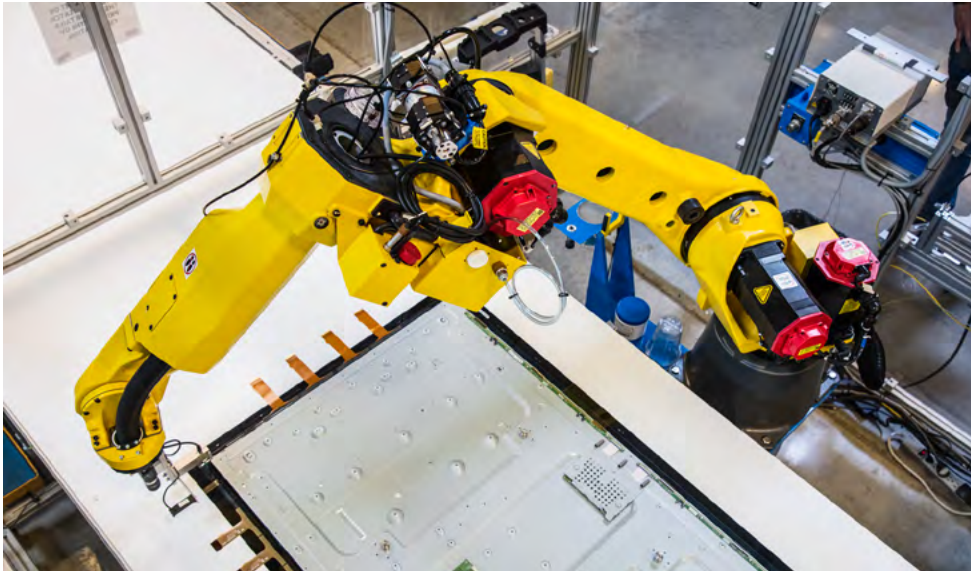
Improve interactions across the value network

Enable teams to securely collaborate in the most natural way possible by implementing modern productivity tools.

Utilize AI to drive innovation

Harness AI to create systems of intelligence that help drive sustainable innovation and create differentiated products and services.

Monetize connected products *Increase margins from digital products and services with intelligent business apps.*

As demand for smart, innovative products grows, customers are looking to deliver value closer to the consumer, creating a need for increased customization and configurability. Microsoft helps you turn this trend into an opportunity for growth by using intelligent business apps

80%

Percent of anufacturers who expect improved factory connectivity to increase output.

"Annual Manufacturing Report 2017," Hennik Research, May 2017.

to enable customized, data-driven products and services that create differentiation, generate customer insights, and increase profit margins in the new service economy.

With aggregated product data in the cloud, business can better assess performance, resolve issues, and develop innovative new designs with better functionality and usability.

Insights from connected products can be leveraged to establish a cycle of continuous product innovation, where products and services are quickly iterated upon and deployed through the cloud.

And modern AI and advanced analytics capabilities can be used to improve productivity and performance across the organization, analyzing behavior and trends in real time.

Monetize connected products

→ Create consistent experiences across channels
Develop and implement new customer-centric business models and build brand awareness and customer loyalty by delivering rich and consistent experiences across multiple devices.

Enable custom configurations
Utilize intelligent systems to determine how customers will use products, and enable quick, flexible custom configurations that meet their needs.

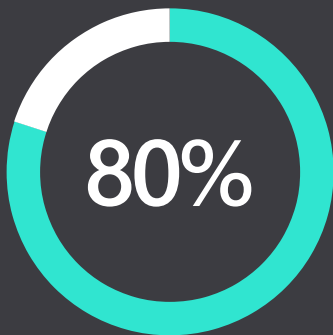**Keep customers engaged through their lifecycle**
Establish 1:1 customer relationships, reward and incent the channel in new ways, and deliver new value with connected products.

Create new sources of revenue
Utilize insights from connected products to drive continuous product innovation, and develop products and services quickly in the cloud.

Use AI and mixed reality to fill skill gaps
Take advantage of AI and advanced analytics capabilities to improve productivity and performance across the organization.

Create intelligent value chains *Open new markets with secure and intelligent edge and cloud.*

Today's manufacturers are looking to maximize their innovation investments and open new revenue streams. Microsoft empowers manufacturers to propel their Industry 4.0 leadership into new markets. Leverage Microsoft's secure and intelligent edge and cloud to eliminate infrastructure barriers and develop the next generation of products that reduce waste, drive social impact, and foster sustainability across value chains.

With intelligent systems fueled by unified data, Dynamics 365 for Finance and Operations is enabling businesses to convert fragmented supply chains into sustainable, integrated value networks.

By synchronizing logistics across manufacturing sites, warehouses, and transportation models, businesses are able to optimize their

68%

Percent who expect AI automation applications in supply chain in the next 2 years.
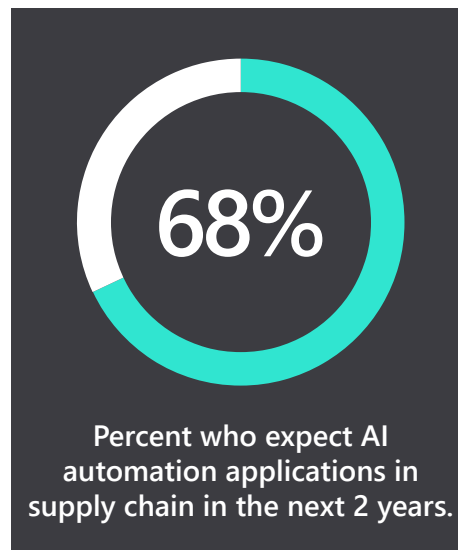
supply chain and reduce costs. Unified data from across the organization in the cloud helps streamline and automate processes, maximizing efficiency while improving security and compliance. And flexible deployment options help cut costs and limit waste, allowing businesses to grow at their own pace.

Create intelligent value chains

Convert supply chains to integrated networks
Simulate network design in real time to identify opportunities to enhance sustainability across value chains.

Develop sustainable products
Use cloud-based high-performance computing to create intelligent products that meet sustainability goals.

Deploy cutting-edge cloud infrastructure
Deploy new services and experiences on a global scale by using a scalable and modular infrastructure.

Drive secure process and regulatory compliance
Enhance document review and approval processes, meet regulatory requirements, and reduce violations of data governance and protection policies.

Reduce the number and severity of cyberattacks
Prevent identity compromise, secure apps and data, expand device controls, and safeguard infrastructure from evolving security threats.

Our mission

At Microsoft, we're continually exploring new ways to empower our customers to better manage change and transform their businesses. We imagine a better world for business users everywhere. One that uses modern, mobile, enterprise-ready intelligent business apps from the cloud that are as easy to use as the consumer apps that help us all get rides, book rooms, listen to music, and take actions to improve our health. A world where things simply work and where they work simply.

In the end, our story is not about 0s and 1s but rather about how we enable people to change the world for the better. Through our integrated set of tools and ser-vices —including Dynamics 365, Microsoft 365, LinkedIn, and Azure—we are empowering every person and every organization on the planet to achieve more.

How can you get Dynamics 365?

Get started with Dynamics 365 today

- Options for one or many products
  - Choices for any type of user
- Editions for businesses of any size

GET STARTED ›

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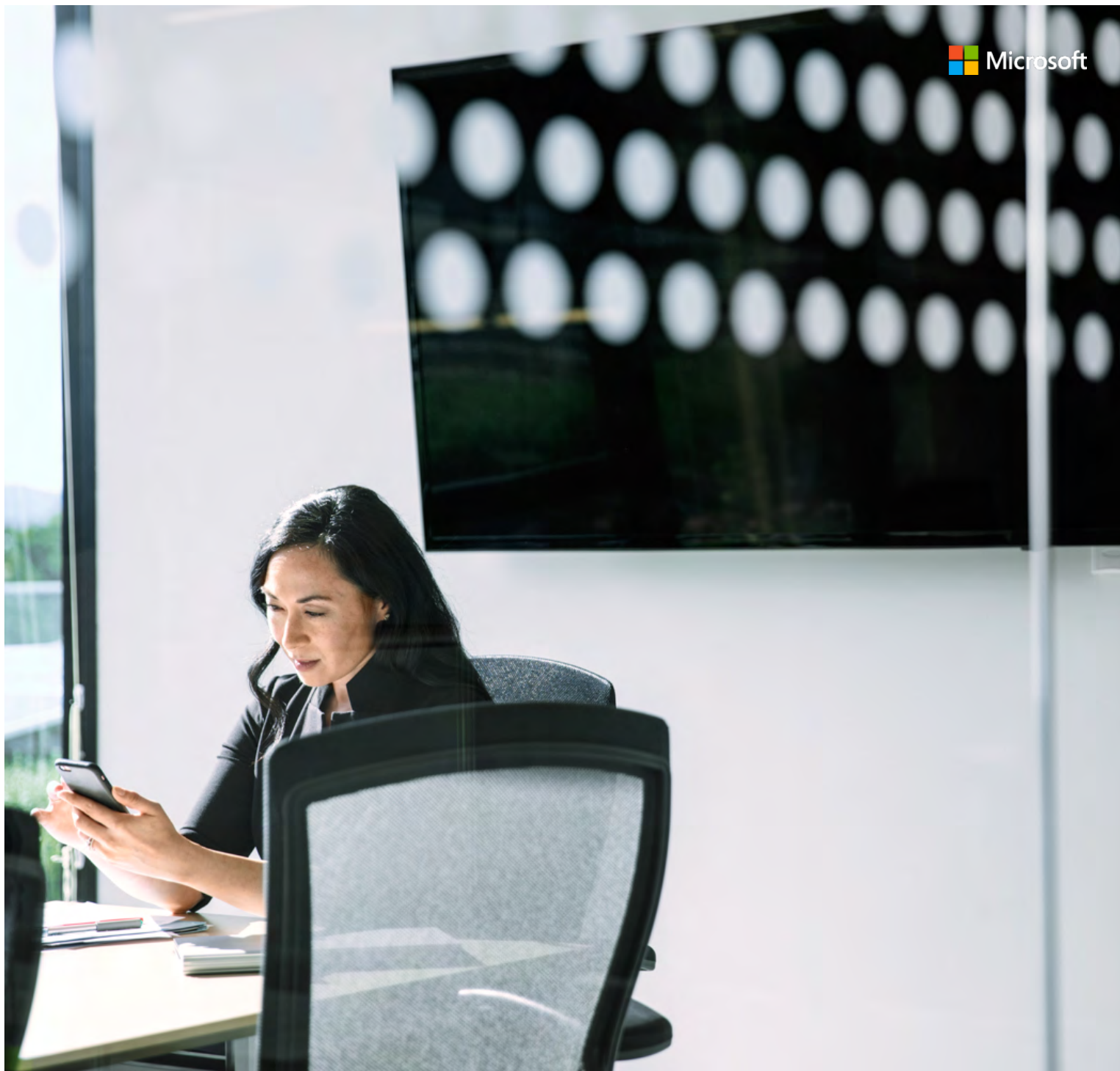
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