Navigating the fourth industrial revolution to the bottom line

MANUFACTURING Institute

pwc

As the fourth industrial revolution (4IR) moves from buzzword to reality, companies are making progress in implementing new technologies, but scaling and linking investment to value remain a work in progress

The fourth industrial revolution (4IR) has been met with both enthusiasm and fence-sitting. While sentiments and experiences have been mixed, most business leaders are now approaching 4IR with a sense of measured optimism. Indeed, larger systemic changes are underway, including building pervasive digital operations that connect assets, developing connected products and managing new, real-time digital ties to customers via those products. While manufacturers recognize the potential value of advanced technologies and digital innovation—particularly robotics, the Industrial Internet of Things (IIoT), cloud computing, advanced analytics, 3D printing, and virtual and augmented reality—they are still deliberating how and where to invest and balancing the hype with their own level of preparedness. Meanwhile, they're also well aware of the significant changes 4IR will bring to a new manufacturing workforce—that is, one that is increasingly symbiotic and increasingly beneficial for many workers and manufacturers alike.

This narrative is reflected in a new survey of US-based manufacturers carried out by PwC and The Manufacturing Institute, the workforce and thought leadership arm of the National Association of Manufacturers. We see a definitive—and, indeed, inevitable—shift to 4IR as companies seek to integrate new technologies into their operations, supply chain, and product portfolio. At the same time, they acknowledge that scaling, justifying 4IR investments, and dealing with uncertainty surrounding use cases and applications usher in a new set of challenges.

Some key survey findings include:

- While the sector as a whole is making assertive forays into 4IR, many manufacturers still inhabit the awareness and pilot phases. Nearly half of manufacturers surveyed reported that they are in the early stages of a smart factory transition (awareness, experimental, and early adoption phases).
- Manufacturers do expect the transition to accelerate in the coming years—73% are planning to increase their investment in smart factory technology over the next year.
- While we see a number of fence-sitters, the bulk of manufacturers are indeed prioritizing 4IR, the digital ecosystem, and emerging technologies. 31% report that adopting an IoT strategy in their operations is "extremely critical" while 40% report that it's "moderately critical."
- About 70% of manufacturers say the biggest impacts of robotics on the workforce in the next five years will be an increased need for talent to manage in a more automated, flexible production environment and the opening of new jobs to engineer robotics and their operating systems.

I 4IR adoption: Where we are now?

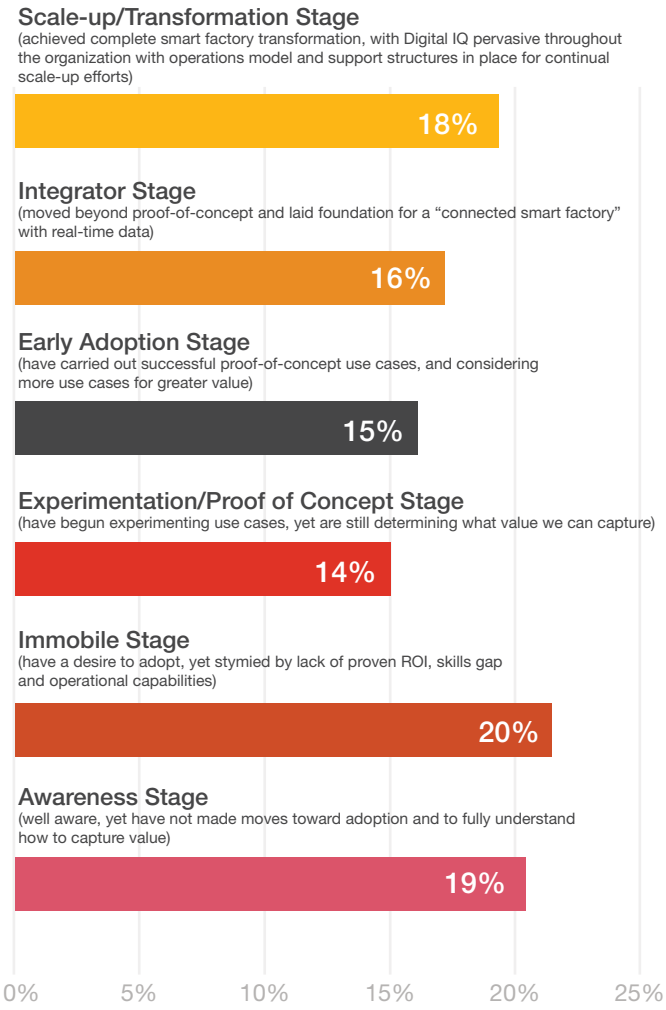
The 4IR adoption curve is still well-populated… Despite performance improvements and lowered cost barriers of most 4IR technologies, the manufacturing sector still exhibits a broad range of adoption and experiences. Essentially, we see three broad groups: first-movers, fence-sitters and laggers, as has been the case with most emerging technologies throughout each of the four industrial revolutions. Manufacturers are fairly evenly spread across the smart factory tech adoption curve—spanning from "the awareness stage" to the "fully scaled, transformation stage." Indeed, while there are certainly signs of activity in investment and adoption, only around 20% of companies are implementing smart factory technologies at scale.

Those that have effectively defined their use cases with a focus on outcomes rather than technology are seeing early wins, and are looking for ways to generate even more value.

…While adopters have identified clear signs of success. Though most manufacturers are still climbing the 4IR adoption curve—albeit at different speeds—those that have made progress are reporting a modicum of performance boosts measured by productivity gains, reduced labor costs, new revenue streams from IoT-connected products and services, as well as improved workforce retention and worker safety. Those that have effectively defined their use cases with a focus on outcomes rather than technology are seeing early wins, and are looking for ways to generate even more value.

Manufacturers evenly distributed on the 4IR tech adoption curve

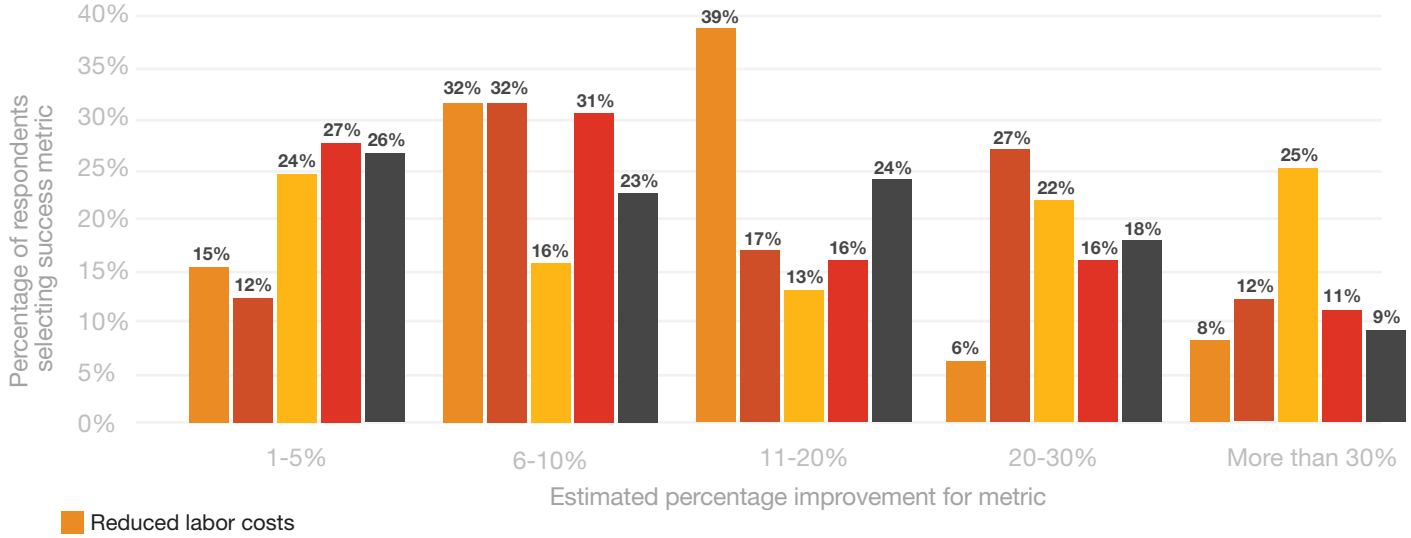
Q. At what stage would you estimate your organization is on the "Smart Factory technology" adoption/use-case curve?



Number of respondents: 96
Source: 2019 PwC/The Manufacturing Institute Smart Factory Survey

Productivity gains, new revenue streams among top successes from 4IR tech adoption

Q. In the last year, what were the top three metrics used to measure the success of your Smart Factory technology use-cases and what was the estimated percentage of improvement in each metric chosen?



Number of respondents for each sub-question: Reduced labor costs: 98; Productivity gains through operational efficiencies: 98; Reduced injuries to workers due to machines doing more manual labor: 97; New revenue streams from IoT-connected products: 95; Greater workforce retention: 96
Source: 2019 PwC/The Manufacturing Institute Smart Factory Survey

The Takeaway

While the sector as a whole is making assertive forays into 4IR, many manufacturers still inhabit the awareness and pilot phases. Nearly half of manufacturers surveyed reported that they are in the early stages of a smart factory transition (awareness, experimental, and early adoption phases). And, of those using metrics to track the success of 4IR technology adoption, areas in which they are seeing success include productivity gains, reduced labor costs, new revenue streams from IoT-related products and services and reduced injuries and greater workforce retention.

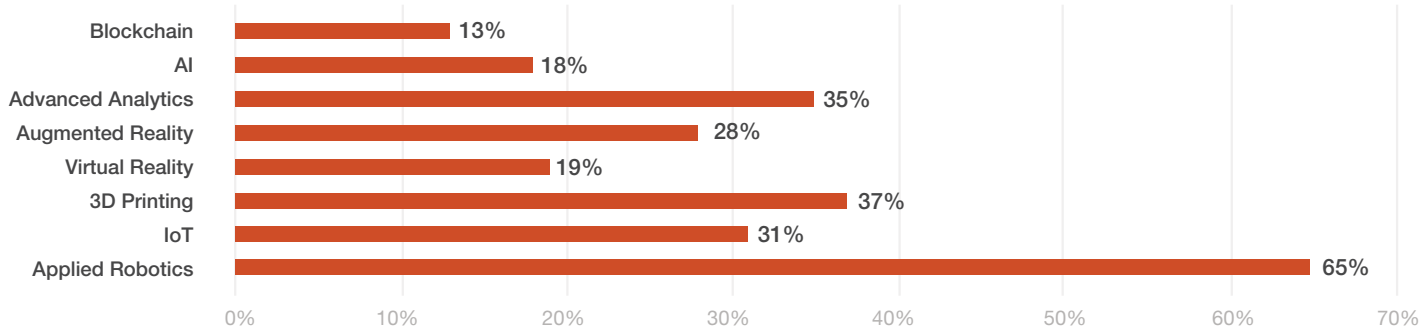
4IR by the numbers

- Some $650 billion has been invested in 4IR technologies globally since 2012 (PwC estimates)
- Industrial robot shipments hit 46,000 in the Americas in 2017 (up from 28,000 in 2012) [1]
- Number of IoT connected devices globally totaled 7 billion in 2018 and projected to exceed 21 billion by 2025[2]
- The global IoT sensors market was valued at $9.5 billion in 2018, and estimated to hit $65.8 billion by 2027[3]

1. "IFR World Robotics 2018", International Federation of Robotics, 2018.
2. "State of the IoT 2018" IoT Analytics, August 8, 2018.
3. "The global IoT sensors market accounted for US$ 9.46 Bn in 2018 and is expected to grow at a CAGR of 23.9% over the forecast period 2019-2027, to account for US$ 65.79 Bn in 2027" PR Newswire, March 11, 2019.

4IR tech: applications in operations

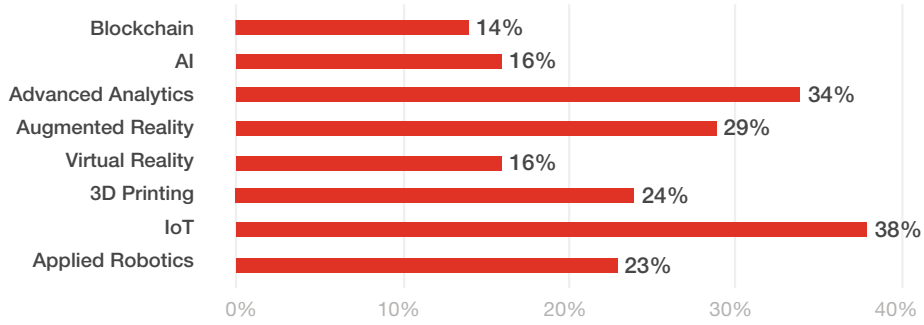
Q. Over the past three years, what new applications/use cases has your organization deployed in your operations?



Source: 2019 PwC/The Manufacturing Institute Smart Factory Survey

4IR tech: applications in the supply chain

Q. Over the past three years, what new Smart Factory applications/use cases has your organization deployed in the supply chain?



Source: 2019 PwC/The Manufacturing Institute Smart Factory Survey

What 4IR technology is being deployed… and how? Given its decades-long entrenchment in manufacturing, robotics is the clear leader in 4IR technology adoption. Yet, digitalization of operations, the supply chain, and end-products hinge on artificial intelligence, IoT, and advanced analytics, all of which serve as the connective tissues throughout any 4IR ecosystem; unsurprisingly, then, manufacturers report relatively robust uses cases they have implemented with these technologies over the last three years. 3D printing, augmented and virtual reality, too, have seen healthy use-case deployments over this period.

4IR technologies are also being adopted at varying paces. Robotics, a strong driver in production cost reductions, is the clear leader in use-case deployments. Yet, IoT and advanced analytics are becoming mainstreamed as businesses increasingly collect and analyze data across their organizations from the supply chain to production to IoT-enabled products. Other technologies, such as artificial intelligence, blockchain, augmented/virtual reality and 3D printing, have achieved traction among manufacturers, but have yet crossed the threshold to mainstreamed adoption.

Overall, manufacturers seem to be choosing 4IR technologies in numerous and creative ways, and the power of creatively applying technology could perhaps be more important than the technology itself. That could mean—to offer just a few examples—an increasing reliance on sensors and artificial intelligence to predict a failing part; predicting quality faults through richer analytical models built on vastly more types and sources of data; connecting field service personnel with augmented and virtual reality to gain access to repair and maintenance information data and images; teaching machines and robots to assess and react to worker safety risks; or reinventing spare parts development and production via 3D printing.

The Takeaway

Robots have long been a part of production, but what underpins the transformative nature of 4IR goes far beyond machines. Artificial intelligence, machine learning, IoT, and advanced analytics are opening up powerful new avenues for manufacturers to capture more value from technology across the value chain, including operations, supply-chain management, and products. To maximize their 4IR investment, organizations must identify and build on the advanced capabilities that are borne out of connectivity. Naturally, such connections are myriad and will likely only increase. Companies, then, need first to successfully identify the right outcomes that will produce returns, then identify the new connections (and actions upon those connections) that need to be made to yield desired outcomes.

Additionally, these findings suggest that the industry is building a critical mass of experience and use cases in manufacturers' deployment of 4IR. This pool of experience will likely serve to further inform all 4IR stakeholders as more and more enterprises rise up the adoption curve (from manufacturers to consumers to developers of 4IR technology) and answer, based on empirical evidence, some core questions, such as:

- How best to roll out successful 4IR pilots?
- How to ensure use cases are cyber-secure?
- How to graduate from pilots to scaled-up and integrated applications?
- What are the implications for current operating models and, indeed, operations strategies?
- How to ultimately integrate technologies throughout and beyond an organization and create enterprise-wide "4IR ecosystem"?

II 4IR adoption: Driving growth and resiliency

Pivoting from 4IR pilots to monetization. Despite the uneven nature of adoption of 4IR tech, companies are nevertheless looking to forge ahead. So, while companies may still have questions about the return on investment or what other value 4IR technologies could possibly yield, they recognize that moving forward or establishing themselves as early adopters could lead to a competitive advantage. Their challenge, then, is navigating that level of ambiguity and relying heavily upon capabilities to move from ad hoc pilots to coordinated, end-to-end digital operations innovation.

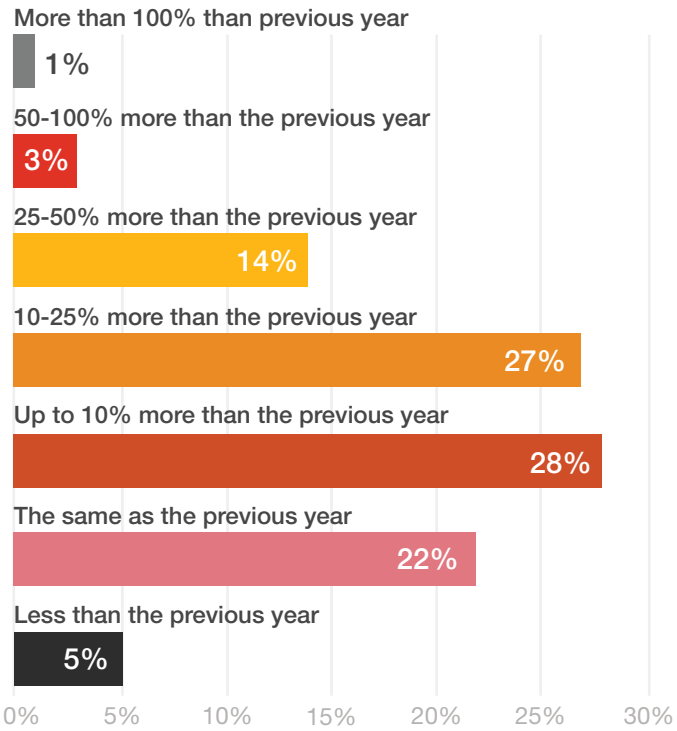
Following the money into the 4IR ecosystem. Of manufacturers investing in 4IR technology, more than half plan to increase their investments by up to 25% over the next year against the previous year. Even without a defined picture of the return on investment, organizations are funding a digital operations transformation for their long-term goals including:

- Improvements in operations (productivity, quality, reliability, and responsiveness)
- Greater visibility into performance, status, and operating risks (which can now be real-time and predictive versus backward-looking)
- Gaining a competitive edge in the marketplace through differentiated, connected product and service offerings
- Faster, more proactive and even touchless customer service.

While such gains may not be immediate, the manufacturers that fold 4IR investment into their overall business strategy and prioritize where to invest may be more likely to pull ahead and guard themselves against any potential economic headwinds.

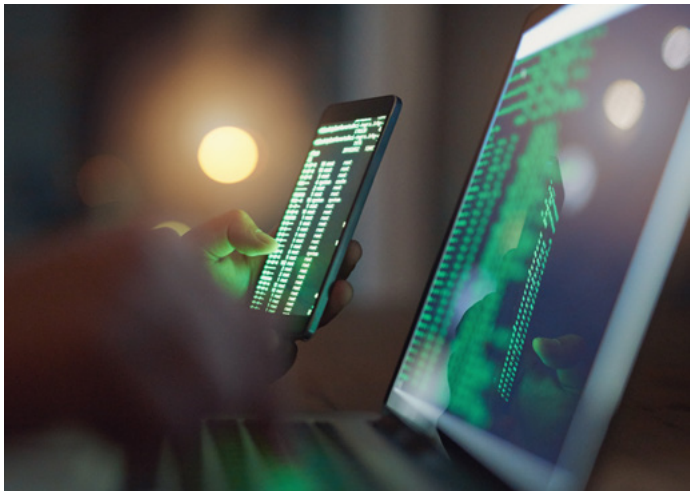
About 70% of manufacturers plan to increase investment in 4IR tech over the next year

Q. Over the next year, to what extent do you change the amount you invest in Smart Factory technology?



Number of respondents: 96
Source: 2019 PwC/The Manufacturing Institute Smart Factory Survey

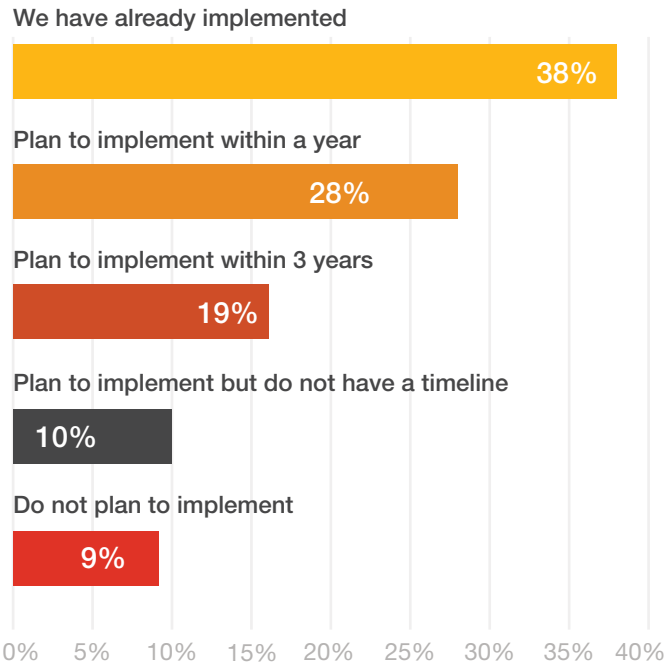
Capturing value from data… Data collection instruments (such as sensors) are at the heart of gathering, sending and analyzing data from machines and devices (from a wind turbine to a stamping press to a forklift or automated guided vehicle). Over the past five years, manufacturers have been on a steep trajectory to install sensors to get real-time vision into the performance of their operations as well as a predictive view into future performance, capitalizing on the potential to collect massive amounts of data and use it to make smarter decisions. On parallel tracks, manufacturers, meanwhile, are also increasingly leveraging existing assets and systems including programmable logic controllers, numerical controls, and data historians to collect and access data.



Furthermore, data collection is leading to enhanced customer product and service offerings and improved customer experience.

80% of manufacturers will have deployed sensors in operations over the next three years

Q. What is your company's timeline for collecting and using data generated by smart sensors to enhance manufacturing/operations processes?

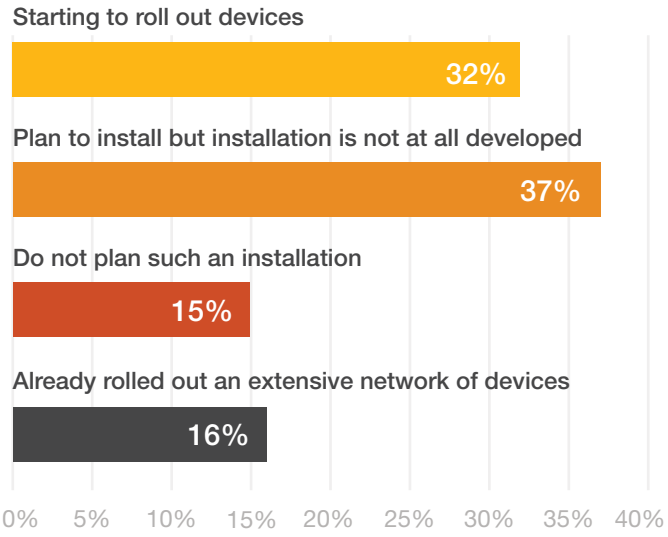


Number of respondents: 93
Source: 2019 PwC/The Manufacturing Institute Smart Factory Survey

...and embedding intelligence, connectivity and interoperability in operations. The data is step one, but it is the refining, sharing and acting on that data that brings real value. IP (Internet Protocol)-connected devices improve data flows, allowing any number of devices to communicate, exchange, and act on information and insights in real time. Over the next few years, more companies will be rolling out this level of device connectivity, likely realizing gains in the speed, efficiency, and accuracy of their business intelligence and operations. According to our survey, nearly half of manufacturers will have installed an extensive network of IP-enabled devices throughout their operations or are in the process of doing so.

About one-third of manufacturers have already deployed IP-enabled devices in operations

Q. How developed is your company's installation of IP-connected devices that improve connectivity in your manufacturing ecosystem?

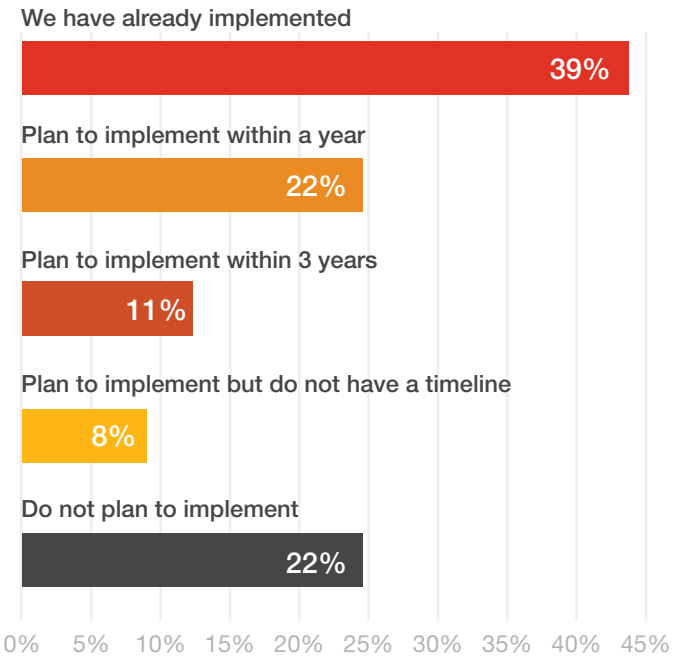


Number of respondents: 92
Source: 2019 PwC/The Manufacturing Institute Smart Factory Survey

The crossover from analog to smart products has already happened. About four in ten manufacturers are already embedding their products with sensor technology that enables users to receive data on product performance. That could mean anything from heavy machinery to home security systems to refrigerators. At the same time, however, about one in three manufacturers either do not plan to make "smart products" or do not yet have a timeline of doing do.

About 60% of manufacturers will have embedded smart sensors in products in the next year

Q. What is your company's timeline for embedding sensors in products that enable end users/customers to collect sensor-generated data?

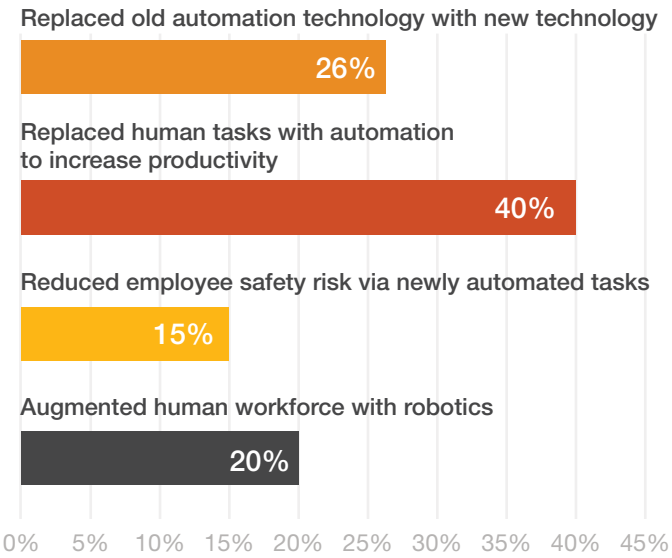


Number of respondents: 93
Source: 2019 PwC/The Manufacturing Institute Smart Factory Survey

Robotics bringing productivity gains… Manufacturers note that robotics have made a significant impact in their operations and enabled greater productivity. They also report other impacts on the workforce, including improved worker safety and "augmentation" of human tasks, perhaps aided by the strong adoption of collaborative robots and semi-autonomous materials handling equipment (such as semi-autonomous forklifts).

Productivity gains is top impact from robotics

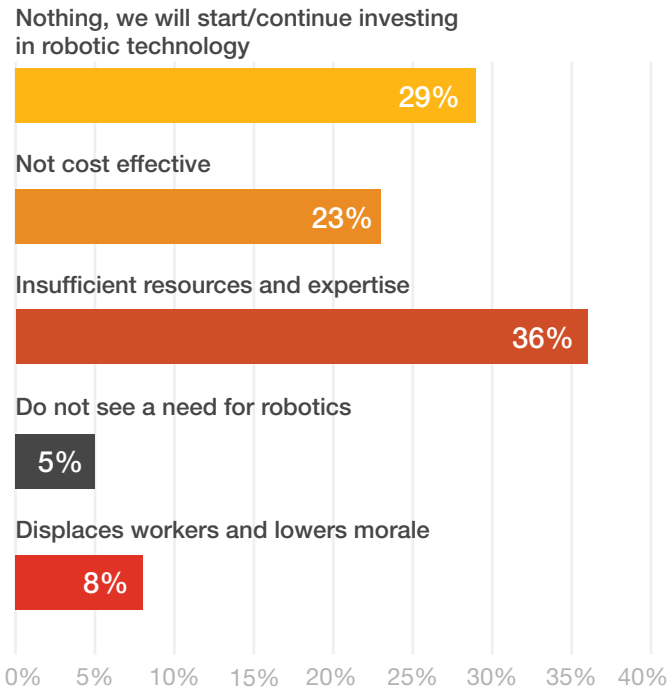
Q. What is the most significant impact robotics technology has had on your operations over the last two years?



Number of respondents: 96
Source: 2019 PwC/The Manufacturing Institute Smart Factory Survey

Expertise shortfall limiting investment in robotics for about one-third of manufacturers

Q. Looking ahead to the next 3 years, what would limit your future investment in robotic technology?

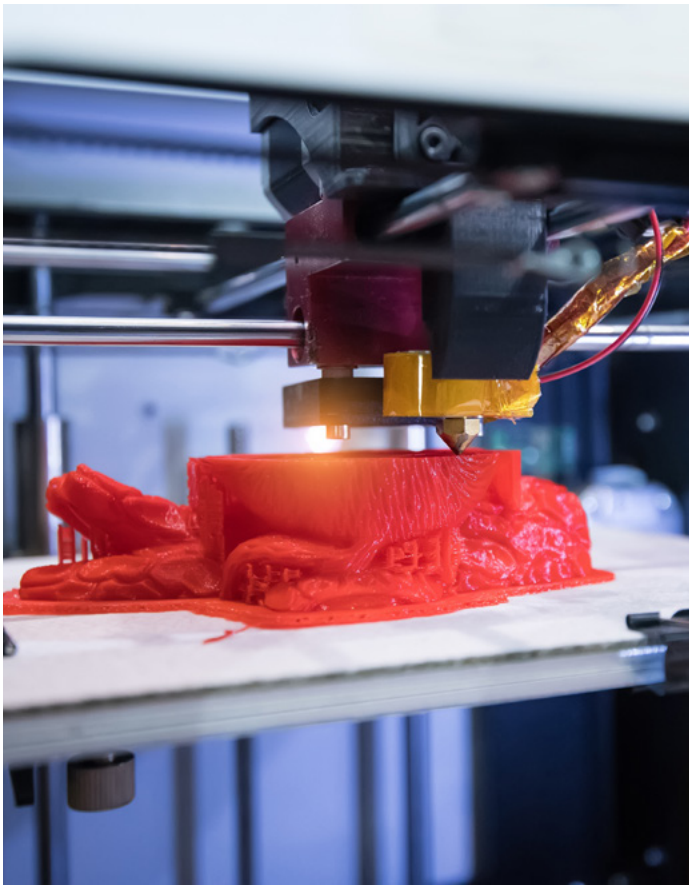


Number of respondents: 84
Source: 2019 PwC/The Manufacturing Institute Smart Factory Survey

…Yet challenges remain in expanding robotics networks. Our survey found that more than one in three manufacturers reported that insufficient resources and expertise could limit their investment in robotic technology over the next three years. However, a higher percentage of small and medium-sized enterprises experienced this potential adoption barrier (42%) compared to large manufacturers (27%). This points to a larger 4IR challenge that companies face across the board—building a deep bench of robotics capabilities that can deliver returns on investment quickly enough to justify the high costs in capital and human resources. While some companies are building more advanced robotics capabilities to derive more value from automation (e.g., machine learning and artificial intelligence which enable robots to take on more complex tasks) this requires considerable investments of both resources and, typically, a rallying of expertise and skill sets across numerous areas of the organization.

The Takeaway

There is little doubt we've hit the tipping point of 4IR innovation adoption, but how quickly this adoption will be mainstreamed and scaled up remains an open question. Companies have found some areas in which to achieve quick wins and develop use cases, but to see return on a larger transformation, they will likely have to invest further in the foundational building blocks—AI, machine learning, IIoT—while they flex new muscles and build new capabilities. Rethinking 4IR beyond shop-floor productivity boost can result in strengthened operations, improved strategic decision making, customer experience advantages, and completely new ways of working. As manufacturers continue to test their assumptions and ambitions surrounding the ROI of 4IR technologies, they will increasingly look at both the short-term and long-term benefits that 4IR investments can yield. Opening up these possibilities can help manufacturers reimagine their role and set themselves up for long-term and enterprise-wide success and resilience in the face of external change, such as an economic downturn.



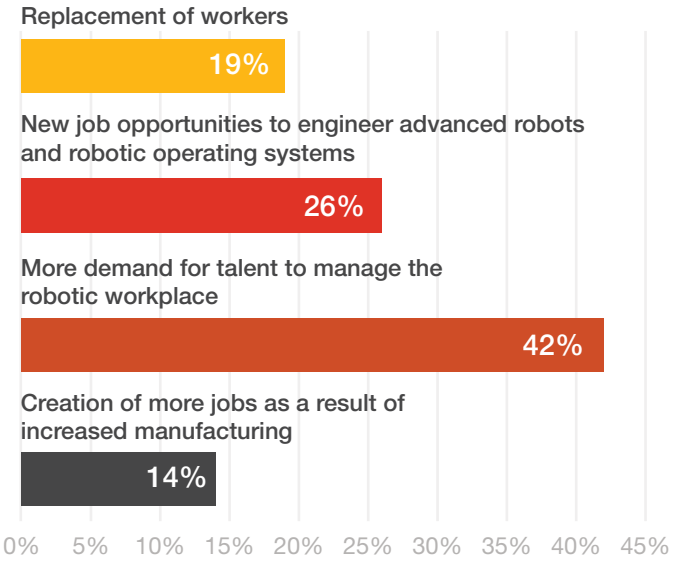
III The 4IR Workforce of the Future

The new manufacturing workforce paradigm is here… Much has been said about automation replacing jobs for workers which has created some uncertainty (and even consternation) among some in the labor force. Over the years, repetitive, mundane tasks have been given over to machines, and manufacturers note that employing robotics versus manpower has led to fewer injuries on the job, reduced labor costs, and improved productivity. Yet, a closer look suggests that while 4IR could make some jobs redundant, it also presents new opportunities for workers.

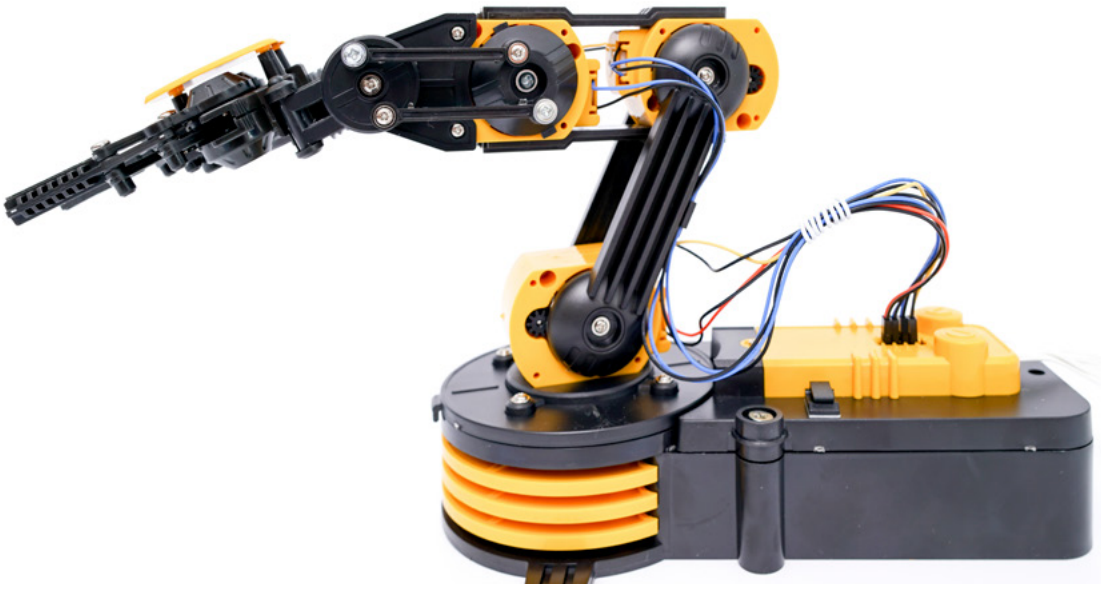
…Does it mean a brighter outlook for people? In fact, only 19% of manufacturers think the biggest impact of robotics will be worker replacement, according to our survey. The bulk of respondents, however, note that robotics can create new job opportunities triggered by rising demand for engineering talent as well for managers of the robotics workforce.

Pressing demand for new talent to manage robots

Q. What will be the biggest impact of robots on the US manufacturing workforce in the next 3-5 years?



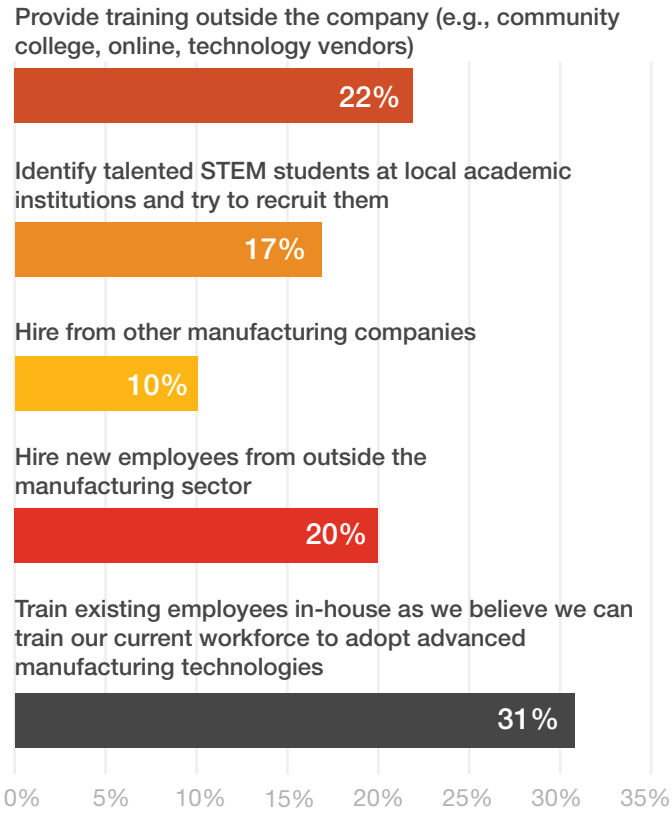
Number of respondents: 86
Source: 2019 PwC/The Manufacturing Institute Smart Factory Survey



A shift in skills-and-competencies demand?
Manufacturers have long sought skills associated with physical and manual labor, but digital innovation in operations requires a new skill set, including technological and engineering skills and analytics acumen. The important question, then, is how manufacturers will fill these positions. Most are taking an upskilling and reskilling approach and training their existing employees on using and managing new technologies, which also addresses the challenge of worker displacement due to automation.

Manufacturers working on numerous fronts to upskill workforce

Q. How is your company trying to raise the level of its employees' advanced manufacturing skills?



Number of respondents: 93
Source: 2019 PwC/The Manufacturing Institute Smart Factory Survey

The Takeaway

As with previous industrial revolutions, the nature of jobs will change. More and more manual and physical labor roles (especially those that are repetitive or dangerous) will likely be replaced by automation technology. However, our survey suggests that some manufacturers see now as the time to create more value from their existing employees through upskilling and reskilling (as well as bringing on new talent) in order to reap the rewards of a productive, engaged workforce—and, perhaps more important, a safer, more attractive workplace.

IV Building out a 4IR strategy

As manufacturers scale their investments, the biggest question will be how they measure their return. Venturing into uncharted 4IR territory naturally means that one of the largest barriers business leaders face is an insufficiently defined business case that guides their investments; yet waiting to develop one and lagging behind in 4IR adoption could put some companies at a disadvantage down the road.

So, what should manufacturers consider to extract the most value from their 4IR investments? We have identified four strategies that can help organizations scale their efforts and tie them back to the bottom line.

- ***Start with the outcomes that matter to the business.*** It can be tempting to go full steam ahead and embrace 4IR technologies and build new capabilities, but the organizations that do so without first articulating their business needs will likely find that they invest heavily but fall short of expectations of outcomes. By first focusing on desired business outcomes or identifying gaps in their operations, supply chain, or product portfolio, manufacturers will let their business strategy guide their 4IR investments, rather than the other way around. Further, it's important to have a strategic plan for how the company will act on the benefits of 4IR innovation. For example, a company that's spending heavily on equipment repair costs can use 4IR technologies to employ more effective predictive maintenance through sophisticated sensors, advanced analytics, and a strong understanding of the manufacturing ecosystem. Taken together, this can create "micro" benefits of improving uptime and reducing non-value-add maintenance activities; but significant benefits come when there is a plan in place for how to act on operational improvements (e.g., through accepting more volume, redirecting labor to other more valuable sources, or rationalizing capital outlay in light of higher machine reliability).

- ***Think in the context of both growth and contraction scenarios.*** 4IR can help manufacturers maintain productivity in the face of a downturn, but doing so requires a strategic understanding of a company's vulnerabilities and how to address them. For example, during a growth cycle, many companies have deployed 4IR innovations to create capacity (cost and CapEx avoidance); however, in a slow-down, the aim might be market share expansion and price protection, with 4IR innovations implemented to increase operational flexibility and responsiveness or product innovation (for greater customer stickiness and new revenue streams).

- ***Look outside of the organization to scale beyond the pilot phase.*** Ad hoc efforts can help companies identify and develop business cases within the company; however, when the ultimate goal is end-to-end smart digital operations and strengthening advanced analytics capabilities, for example, manufacturers need to consider the full technology stack. This will require identifying partners and vendors in the 4IR ecosystem and building an architecture that enables scaling. For some smaller manufacturing companies, even simply identifying technologies and requirements will be a daunting task. When venturing into tech stack development, it's crucially important that companies have already articulated their business

needs and desired outcomes—this will guide the process and decision making and provide vendors with valuable information to discuss priorities and tradeoffs.

- ***Prepare the workforce for 4IR.*** 4IR brings with it demand for entirely new skills that are in high demand. Manufacturers can get ahead of a potential talent shortage and retain employees by focusing on training, both in-house and outside the company.

The Takeaway

Manufacturers are seeking to balance 4IR hype and reality. And most acknowledge that sitting back and waiting for the inevitable may not be an option. The road may be longer than the hype would have companies believe, but preparing for and embracing change is a muscle many of today's manufacturers are ready to flex. Those that can build on their ad hoc pilots and prioritize investments and strategies with their long-term desired business outcomes will be better positioned to create lasting value for their organization.

Connect with us

To have a deeper conversation about how this subject may affect your business, please contact:

Jeff Sorensen
Partner, Industrial Products Leader, PwC US
(412) 316-2365
jeff.sorensen@pwc.com

Todd Benigni
Principal, Operations Consulting
(312) 298-3192
todd.m.benigni@pwc.com

Bobby Bono
Partner, Industrial Manufacturing Leader, PwC US
(813) 222-7118
robert.b.bono@pwc.com

Karim Bibawi
Director, Advisory
(617) 530-5140
karim.bibawi@pwc.com

Barry Jaruzelski
Principal, Industrial Products Advisory Leader, PwC US
(917) 648-7148
barry.jaruzelski@pwc.com

Steve Pillsbury
Principal, Digital Operations Leader, PwC US
(312) 298-2257
steve.pillsbury@pwc.com

Juliane Stephan
Director, Operations Strategy
(312) 208-8136
juliane.stephan@pwc.com

The Manufacturing Institute

Carolyn Lee
Executive Director
202-637-3139
clee@nam.org

Chad Moutray
Director of the Center for Manufacturing Research
202-637-3148
cmoutray@nam.org

Editorial team:

Chris Sulavik
Senior Fellow, US Thought Leadership Institute

Tom Waller
Director, US Industrial Products