Deloitte. Insights

MANUFACTURING Institute

# 2018 Deloitte and The Manufacturing Institute skills gap and future of work study

A DELOITTE AND THE MANUFACTURING INSTITUTE SERIES ON THE SKILLS GAP AND FUTURE OF WORK IN MANUFACTURING

The United States is experiencing near-historic low unemployment amid an extended period of economic expansion. The skills shortage that Deloitte and The Manufacturing Institute have been tracking for the past 17 years continues to swell, threatening to impede the current growth in the US manufacturing industry. This fourth skills gap study explores the depths of today's talent shortage in manufacturing, how jobs are changing due to technology and automation, and what measures manufacturers could take to solve today's shortage while preparing their future workforce for success.

# Contents

Introduction | 2

Measuring the depths of the current skills shortage | 3

Digital impact: How are skills shifting? | 7

Approaches to patch the gap in the short term | 11

Final thoughts | 16

Endnotes | 17

# Introduction

THE US ECONOMY is humming along in a period of remarkable expansion, marked by notable contributions from the manufacturing industry. The sector has been consistently contributing to over 10 percent of the national gross domestic product (GDP) and represented more than 8 percent of all US employed population in 2017.[1] The contributions of the manufacturing sector seem to become more apparent when we consider its multiplier effect on the economy and jobs. Every dollar in output from the manufacturing industry generates another US$1.89 of additional value and every direct job creates 2.5 additional jobs in the US economy.[2] It's no surprise then that most manufacturers express strong optimism for the economy and jobs generation in the months to come.[3]

However, while most manufacturers may expect jobs to grow, they must contend with one of the tightest labor markets in recent history, including a situation where the number of open jobs exceeds the number of people looking for work.[4] For manufacturers, filling open jobs has been an ongoing challenge in recent years, but the current conditions are reaching serious levels.

Deloitte and The Manufacturing Institute entered their fourth skills gap study with an interest in reevaluating their prior projections and moving the conversation forward to today's hiring environment and the future of manufacturing work. The results appear to highlight a widening gap between the jobs that need to be filled and the skilled talent pool capable of filling them. Beyond the numbers, the study probes the depths of today's talent shortage in manufacturing. It explores how jobs are changing due to technology and automation, and what measures manufacturers could take to solve today's shortage while preparing their future workforce for success.

### METHODOLOGY

Deloitte and The Manufacturing Institute have been tracking the skills shortage for the past 17 years and have come up with their fourth skills gap study. Its primary focus is to engage manufacturing executives, industry leaders, public office, and educational training resources in an active dialogue to understand the expanse of the skills shortages in manufacturing, identify future skills needed, and develop concrete solutions toward filling the gap. The study includes an online survey of more than 400 US manufacturers, interviews with executives from manufacturing organizations, extensive analysis of secondary data, and economic projections from Deloitte's economic team based on our analyses.

# Measuring the depths of the current skills shortage

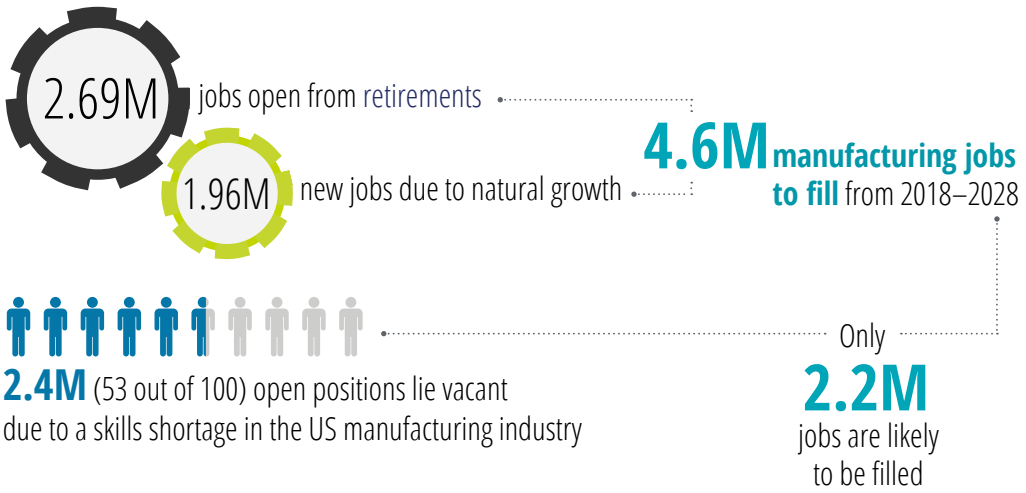
AS RECENTLY AS August 2018, there were 508,000 open jobs in US manufacturing, part of the best annual job sector gain in more than 20 years.[5] While the job gains are positive indications that the industry continues to recover from the Great Recession and reflect strong production levels, it also means that finding talent with the right skills to fill the open jobs could reach crisis proportions. As one manufacturing executive noted, "With the positive turn in the economy, we don't have enough job candidates with the right skills and work ethic to fill our openings, and this is making it difficult for us to accept the orders our vendors are asking us to complete."[6] This talent crunch is hitting most manufacturers where it matters most—the top line. Fifty-one percent of executives cited "maintaining or increasing production levels to satisfy growing customer demand" as the biggest challenge arising from not filling open jobs in the next three years.[7]

## The gap continues to widen

Job shortages are not new to manufacturing, especially in recent years. Deloitte and The Manufacturing Institute have captured the widening gap since the United States emerged from the Great Recession, and the current projections indicate

FIGURE 1

**The skills gap may leave an estimated 2.4 million positions unfilled between 2018 and 2028**




*Calculated on the basis of 52.7% of the skilled manufacturing positions that are unfilled (per the 2018 survey)
**Retirement age of 66

Source: BLS Data, OEM (Oxford Economics Model), Deloitte and Manufacturing Institute skills research initiative.

an increase in the total unfilled jobs in the next 10 years from 2.0 million to 2.4 million (see figure 1). What *is* new to the talent shortage discussion is many manufacturers' expectation that the situation is about to get much worse.

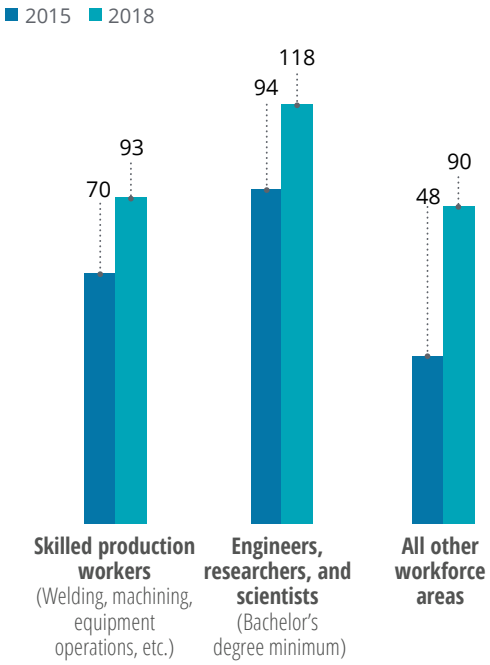
## Skilled jobs are becoming more difficult to fill

The study shows many companies expect job categories where they have rated the current shortage "very high"—digital talent, skilled production, operational managers—to triple in difficulty in terms of filling positions in the next three years.[8] In fact, many manufacturers surveyed expect the extent of the skills shortage to increase across all workforce areas in the coming three years. Even at present, many of these jobs are taking longer to fill, stretching out to months of time where a company is missing key workforce to deliver open orders, expand production, or respond to customer needs (see figure 2).

FIGURE 2

**The average time to fill an open job position is on the rise**

Number of days to fill a job position, by categories, 2015 and 2018




Source: 2018 Deloitte and Manufacturing Institute skills gap study.

## Measuring the impact of the skills shortage on future manufacturing economic output

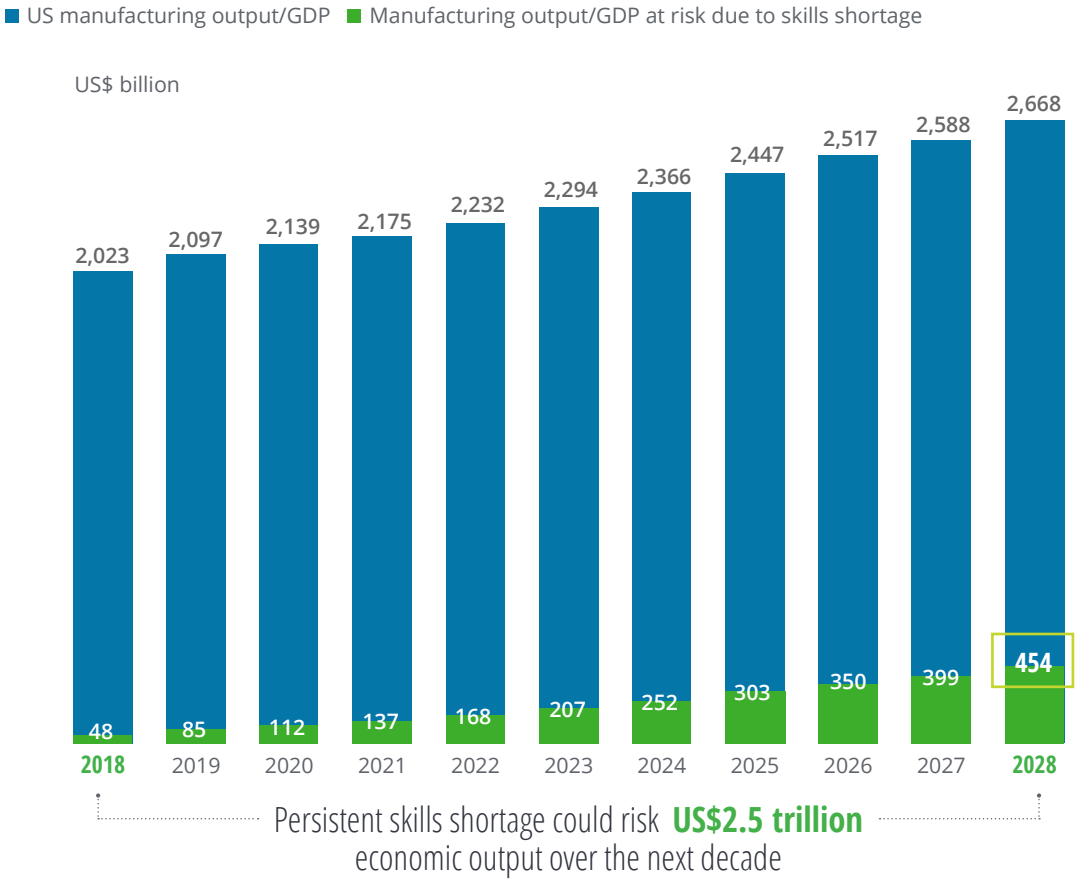
Based on our analysis, Deloitte's economic team created a baseline projection that assumes that by 2028, US manufacturing employment will grow at an average rate of 1.5 percent per year. This implies that as a baseline, the industry would need to employ approximately 1.96 million additional workers between 2017 and 2028 to produce the goods the growing economy could demand. However, the lack of skills identified by manufacturing industry executives and impending retirements suggest the industry could experience employment bottlenecks, leading to a potential 2.4 million jobs going unfilled, with the risk of limiting production below these projections. By 2028, in the base case, additional manufacturing value added of US$454 billion could be at risk if qualified workers cannot be found to fill the open jobs, which could account for about 17 percent of the total US forecasted manufacturing GDP of US$2.67 trillion (see figure 3).

## Linking job shortages to shifting skills needed in manufacturing

A notable shift seems to have occurred since the 2015 study in what manufacturers see contributing to the current talent shortage. Then, the retirement of baby boomers topped the list, followed by strength of the economy.[9] The current study reveals that most manufacturers believe that the No. 1 cause of the skills shortage is "shifting skill set due to the introduction of new advanced technology and

FIGURE 3

## Skills shortage could put US$454 billion of manufacturing GDP at risk in 2028 alone




Note: 2017 base year.
Source: Data from BLS and Oxford Economics Model, Deloitte and Manufacturing Institute skills research initiative.

automation," followed by "negative perception of students/their parents toward the manufacturing industry." Baby boomer retirements complete the top three causes of today's skills shortages, according to manufacturing executives.[10]

It may come as no surprise that shifting skills would top the list, as manufacturers find themselves in the midst of the Fourth Industrial Revolution, one that is defined by its use of advanced technology to transform work throughout an organization.[11] Half of the manufacturers in the study expressed that they have already adopted technologies such as robots, cobots, machine learning, and artificial intelligence (AI). In the presence of increased human–machine teaming and access to insights surfaced via the Internet of Things (IoT), the types of skills that employees need to possess are rapidly evolving, and it seems increasingly difficult for the workforce to keep pace.

## DELOITTE'S US MANUFACTURING EMPLOYMENT PROJECTIONS TO SUPPORT PRODUCTIVITY

These projections are based on 10-year extensions of *Deloitte's 2018 Q2 US Economic Forecast*.[12] The forecasts are calculated using the Oxford Global Economic Model, a standard model used for a variety of forecasting and policy analysis purposes. The model projects quarterly real quantities for major components of GDP:

- Consumer spending
- Fixed private investment
- Inventory investment
- Exports
- Federal investment in defense
- Federal investment, nondefense
- State and local investment*

These final demand categories are the basis for measuring GDP by expenditure. To obtain GDP by industry, the model includes an equation for each one-digit industry code, which translates expenditure components into the industry supply required to produce those components. For example, a dollar of additional exports generates a larger demand for manufacturing output than a dollar of consumption demand. The shares are based on the US Bureau of Economic Analysis's input–output matrix, which measures the supply and demand of goods and services by industry and final demand.[13] This determines the real value added (GDP) for each industry.

*Source: Deloitte analysis; Oxford Global Economic Model.

# Digital impact: How are skills shifting?

The year is 2025. Digital transformation has helped a major industrial manufacturer realize the promise of the Fourth Industrial Revolution, including its product design approach, where digital twin engineers spend their time creating virtual models of the products the company makes. These twins help the company predict and respond to customer problems using real-time data analysis and advanced technologies.[14] The skills these next-generation engineers need include the ability to collaborate across manufacturing disciplines and to interact with customers and partners in ways that today's engineers often do not.

This example, and the additional personas that will be described in Deloitte's future of jobs in manufacturing series, highlight the seismic shift that could occur over the next decade as the Fourth Industrial Revolution completes its transformation of manufacturing. Today, the early stages of digital transformation seem to already be creating a mismatch between the available workers and the skills necessary to fill open jobs. For production workers, it is not the need for STEM degrees (science, technology, engineering, math) but rather the ability to program machines on the plant floor. Increasingly, employers are looking for extended computer skills that enable core production workers to program a CNC (computer numeric control) machine for a new job, or interact with CAD/CAM (computer-aided design/computer-aided manufacturing) and other engineering or manufacturing software. In fact, manufacturing executives stated the top five skill sets that could increase significantly in the coming three years due to the influx of automation and

advanced technologies are: technology/computer skills, digital skills, programming skills for robots/automation, working with tools and technology, and critical thinking skills (see figure 4).[15]

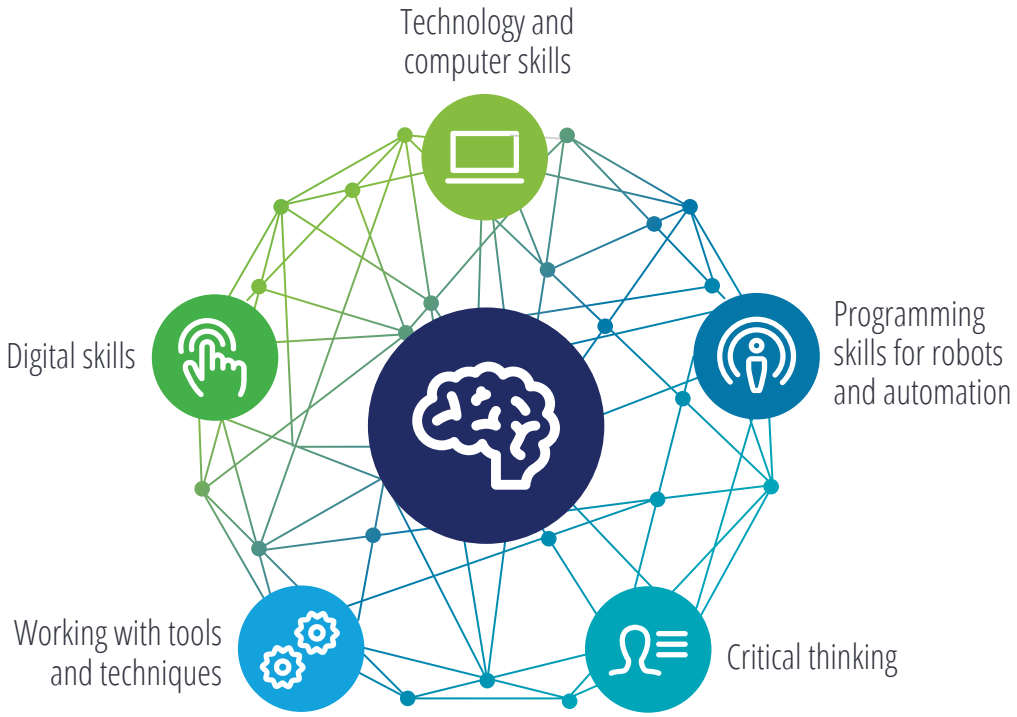
## Expanding "soft" skills in a digital workplace

One of the top five skills—critical thinking—stands out, as it portends a return to "human" skills in the face of technology transformation. As technology could replace many of the manual or repetitive tasks today's jobs entail, it would free up space for skills that are uniquely human, often called "soft" skills. A recent World Economic Forum study found human skills such as critical thinking, creativity and originality, attention to detail, problem-solving, and people management are expected to see an outsized increase in demand relative to their current prominence.[16] Companies need workers that can demonstrate these skills as well as the digital skills necessary to work alongside automation.

In manufacturing, this generally translates to solving problems in production, such as having the

FIGURE 4

**Five key skills are expected to be needed to succeed in the Fourth Industrial Revolution**




Source: Deloitte analysis.

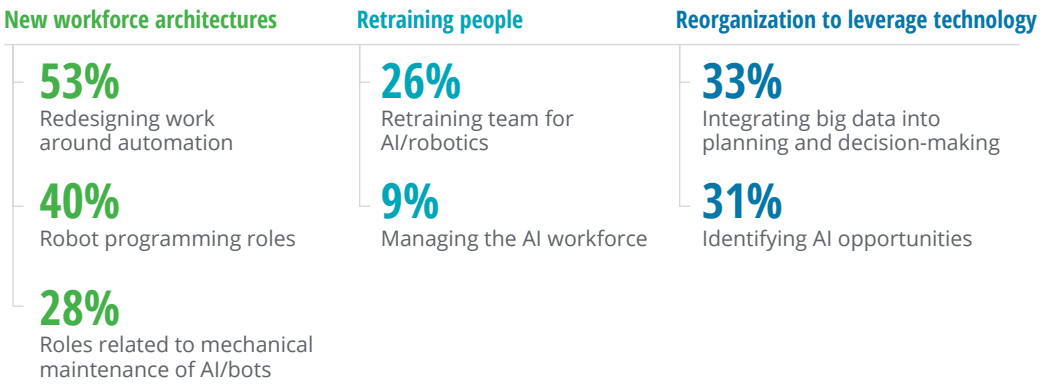
ability to identify quality failures with parts coming off an automated production line and, more importantly, to take actions that remediate the problem in real time. These skills are expected to become increasingly important as automation is added to production lines in the form of robots and cobots. As Deloitte's *2018 Global Human Capital Trends* report explains, many organizations are working hard to put humans in the loop—rethinking work architecture, retraining people, and rearranging the organization to leverage technology to transform business (see figure 5).[17] The broader aim is not just to eliminate routine tasks and cut costs, but to create value for customers and meaningful work for people. The human–machine pairing becomes a means of delivering value.

## Supporting soft skills with the digital toolbox in manufacturing

While the value of soft skills tends to grow in lockstep with the move toward automation, robotics, and artificial intelligence, manufacturing workers can turn to a digital toolbox to support productivity and effectively complete tasks (see figure 6). Deloitte has identified some of the digital tools that could amplify the human skills that are increasingly necessary to support the future work in manufacturing. The *2018 Global Human Capital Trends* study shows that tools such as collaboration platforms, work-based social media, and instant messaging can increasingly support the communication necessary for higher productivity.[18]

FIGURE 5

## A growing number of US manufacturers are finding new ways to facilitate the human-machine integration




Source: Deloitte, *2018 Global Human Capital Trends*, March 28, 2018.

FIGURE 6

## About 67 percent of US manufacturers surveyed expect a positive impact of connected work tools on personal productivity

Percentage of manufacturers who expect the usage of below tools to increase in the next 3 to 5 years

Source: Deloitte, *2018 Global Human Capital Trends*, March 28, 2018.

## TOOLBOX

***The toolbox supports the worker as a whole—in achieving external outcomes such as productivity as well as internally focused ones such as decision-making and learning.***

### Productivity

**Venus** This artificial intelligence (AI)-powered, voice-enabled digital assistant provides a conversational interface for all productivity-related tasks, from scheduling to finding answers to questions and checking the status of products and projects.

**WeAR** It is an augmented reality (AR) wearable device that connects digital twin engineers to IoT devices, and receives work instructions and training. These smart glasses, paired with Bluetooth-enabled scanners and voice guidance, respond to commands and open a pop-up on monocular display, which help boost productivity.

**InstaCap** It captures data automatically using digital technologies such as radio frequency identification (RFID) and speech recognition. It helps collect information from machines, images, or even sounds without manual data entry.

**Symphony** This software suite runs simulations and connects digital twin engineers with other resources—people, machines, and systems, for data-driven digital manufacturing. Using advanced real-time analytics, it helps digital twin engineers create models and optimize manufacturing production performance.

### Decision-making

**Smart Dash** It is a visual display that presents data, live information, and analysis from multiple sources to facilitate informed decision-making.

**Envision** This tool uses machine learning to identify potential problems as well as opportunities to devise solutions that make a positive business impact.

**RealConnect** This application enables an engineer to seamlessly interact with suppliers, partners, customers, and the broader ecosystem.

**Sixth Sense** It is a tool that incorporates machine learning, cognitive computing, and artificial intelligence to detect macro trends in the broader environment.

### Learning

**SkillsPro** This smart learning assistant helps digital twin engineers refresh existing skills as well as learn new and emerging skills. Its conversation mode shares tips and tricks about the tools/techniques that an engineer has learned recently. When synced with an engineer's project planner, it shares a list of skills to be learned for implementation in upcoming projects.

**SmartLab** It facilitates classroom learning using virtual reality headsets and simulation. It tests trainees on a defined skill framework and measures subjective aspects based on their response style. Each trainee receives customized learning objectives.

Note: Toolbox represents some of the tools that the workers of the future could need to perform their daily work. For the full description of the above tools and to explore additional tools, please read *The future of work in manufacturing: What will jobs look like in the digital era?*.

# Approaches to patch the gap in the short term

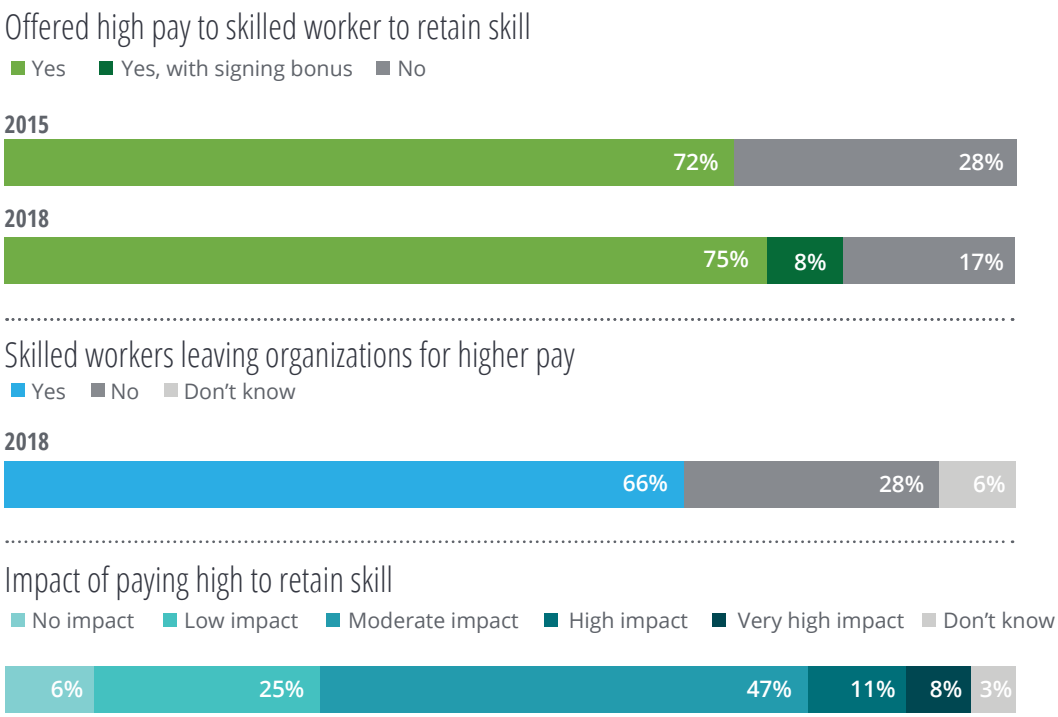
## The age-old lure of paying higher wages

Given the immediacy of job openings and skilled worker shortages that most manufacturers face today, the industry is turning to several short-term, stop-gap measures to fill open jobs. One method is to offer pay increases and signing bonuses to skilled workers. Comparing the percentage of executives willing to take this measure in 2015 and in 2018, there is a noticeable increase (see figure 7). Additionally, there is a cohort of executives offering signing bonuses for certain positions. And, 68 percent of these companies report they are seeing a "moderate," "high," or "very high" impact on the time it takes to fill skilled jobs by offering higher wages or signing bonuses. But, on the flip side, while this might get skilled workers in the door, it does not guarantee they will stay. In fact, the study shows that 66 percent of executives see skilled

FIGURE 7

### Offering higher pay to attract talent is a double-edged sword

Though manufacturing companies are ready to pay more to attract and retain talent, they also find skilled workers leaving their organization for higher pay elsewhere




Source: 2018 Deloitte and Manufacturing Institute skills gap study.

workers leave to accept outside positions that offer higher pay. As one executive noted, "We are setting up a position where skilled workers are jumping to the next offer of higher pay, which doesn't solve our skills shortage long term."[19]

## Outsourcing: A catch-22 situation

As many as 42 percent of manufacturers in the survey indicated a strong affinity toward outsourcing to contract manufacturers as a solution to the current skilled worker shortage. Though outsourcing can help manufacturers increase productivity and save investments in the short term, it poses several risks. The most obvious ones are product quality and intellectual property (IP) protection. However, the more important risk is that manufacturers could be losing out on opportunities to develop high-potential employees and create a steady supply of talent within their factory's walls. With the manufacturing industry gathering steam and continuing to add jobs, a more holistic approach could be needed to solve long-term talent issues.

## Increasing flexibility in the hiring process

The limited availability of active candidates in the job market could make it harder for manufacturers to find the talent that ticks every box. Manufacturers in the 2018 survey indicated they are rethinking whether strict adherence to certain hiring requirements is truly preferable to greater flexibility in the hiring process. In fact, it's now clear to many manufacturers that this flexibility—in other words, prioritizing competencies and potential in job candidates over strict adherence to sometimes arbitrary factors such as years of experience—could actually become increasingly necessary to find and bring onboard the very talent necessary for businesses to thrive. This flexibility, combined with improved employee onboarding and on-the-job training, could help manufacturers identify new employees with good attitudes who can adapt to and fit the needs of the job.

# Forging a path forward to fill the gap for skills and jobs in the future manufacturing workplace

TO SOLVE THE ongoing skills shortages in manufacturing, efforts will likely need to move beyond short-term solutions such as signing bonuses and outsourcing. Deloitte and The Manufacturing Institute identified a number of strategic approaches that manufacturers could take to influence a more positive employment future.

## Engaging the open talent ecosystem

Deloitte's *2018 Global Human Capital Trends* report notes that the traditional employer–employee relationship is being replaced by the emergence of a diverse workforce ecosystem—a varied portfolio of employees, talent networks, gig workers, and service providers that offers employers flexibility, capabilities, and the potential for exploring different economic models in sourcing talent.[20] In the United States, more than 40 percent of workers are now employed in "alternative work arrangements," such as contingent, part-time, or gig work. This percentage is steadily rising—increasing by 36 percent in just the past five years—and now includes workers of all ages and skill levels.[21] Taking advantage of the emerging workforce ecosystem's benefits brings a variety of new challenges, and Deloitte's research shows that most companies are not fully ready. For manufacturers to take full advantage of this emerging workforce to help close the skills gap, it would take a concentrated effort to change the way they structure their work demands, execute talent acquisition, and engage talent within the four walls of the factory. Clearly, the potential is there to incorporate the open talent ecosystem into longer-term strategies for employment in the industry.

## The rise of automation: A salve for job shortages?

The influx of automation in manufacturing continues to disrupt all aspects of operations. It can be found in the form of robotic arms on production lines, cobots that assist humans in manual tasks, and robotic process automation (RPA) to automate routine business processes such as warranty claims processing. In its future of jobs report, the World Economic Forum highlighted that by 2022, machines and algorithms will contribute 42 percent of total task hours, compared to 29 percent in 2018.[22] Initially thought to present a danger to human jobs by replacing them, many manufacturers today are turning toward automation to supplement the low-skilled jobs they cannot fill and instead focus their existing workers on jobs that are either higher-skilled or require uniquely human skills. Nearly half of the executives surveyed in the skills gap study have implemented automation technologies in the form of robots, cobots, machine learning, or AI in the past three years.[23] And one in three of these manufacturers is supplementing their current workforce with automation, often for repetitive

tasks. Further, 64 percent of these executives found that automation helped them overcome some of the challenges they are facing in filling open jobs with qualified talent.

## Tapping the resources of the retiring, experienced workforce

One of the core assets that most manufacturing companies today still possess are workforces that have extremely seasoned workers, many of whom hold intrinsic knowledge of best practices and the nuances of their workplace. Even though these workers are staying longer—most recent data shows the retirement age rising to an average of 66 years[24]—the volume of retirements in the coming decade could be detrimental to the industry. Manufacturers should think carefully about the potential impact a wave of retirements could have on their organization and seize any opportunities to hold on to their proven, committed, and experienced workforce and leverage them as a competitive advantage. The *2018 Global Human Capital Trends* study found that manufacturing companies in the United States are unprepared to leverage the aging workforce, with only 9.2 percent of manufacturing companies creating targeted roles for older workers.[25] However, some manufacturers are moving in the right direction and have launched specific programs to retain the value of their oldest employees.

Michelin North America, through a dedicated retiree program, successfully leverages the knowledge and experience of its retired workforce. The company conducts an off-boarding interview at the time of retirement exits and enquires if the professional would be interested to work in some capacity after their retirement. The names of interested professionals are shared with the various business units within the company, enabling the units to contact the retired employees for short-term project work. Through this unique strategy, Michelin has added approximately 250 people to its overall headcount of 19,000 in the United States.[26]

## Developing in-house training that leverages digital technology

Executives in the current survey highlighted in-house training and learning courses, along with on-the-job training, as the preferred training methods, a finding consistent with the 2015 study. Despite manufacturers' focus on internal training programs, the pace of change still exceeds the extent and capacity of the training programs. Manufacturers should consider increasing investment in training programs and integrating digital technologies to add relevance, helping employees move ahead on the digital curve.

A German industrial goods company employs advanced digital technology to enhance the skills and productivity of its employees. Through an AI headset, Microsoft HoloLens, the company provides on-the-job training to its 24,000 service engineers. The technology helps engineers with visual cues on assembling and disassembling the latest company products in a 3D space, and with viewing equipment schematics in the field while being connected with specialists via a Skype call. The technology improved service times by a factor of four. Several other industrial manufacturers also employ similar AR technologies to upskill and provide live assistance to their workers.

## The value of public–private partnerships

One area perhaps ripe for further exploration by US manufacturers is how to partner with public

agencies to attract, train, and hire skilled workers. Only two in 10 manufacturers indicated that they partner with government and just over three in 10 indicated that they partner with private education/training institutes to train their workforce. Manufacturers often possess the necessary means and the knowledge to train but their access to new workers is limited, while public education is in the opposite situation. The path forward includes manufacturing organizations forging long-term partnerships with public education, industry associations, and agencies to develop programs that build a strong connection with the industry, creating a skilled talent pool for tomorrow's manufacturing environment.

Fluor Corporation, a multinational engineering and construction firm, partners with high schools and the Texas Workforce Commission (a state agency) to provide pre-employment training in skilled workforce areas. The 12-week training courses are based on NCCER (The National Center for Construction Education and Research) curriculum and also include 40 hours of employability skills development. Fluor, through this public–private partnership, aims to make a long-term investment and build a pipeline of skilled talent for the future of manufacturing. The trained graduates are in a better position to be productive for their employers.[27]

## Training the future: Apprenticeship programs

Another approach to building the future talent pool harkens back to a primary form of skills transfer prior to the Industrial Revolution: apprenticeship. Exposure to a skilled trade through an apprenticeship has shown to be a promising pathway for filling many of the skilled jobs that lie open in the manufacturing industry. The government and manufacturers together can fund such education and apprenticeship programs to develop a job-ready stream of qualified workers.

The Apprenticeship Carolina program in South Carolina is a comprehensive partnership model to build a multi-industry talent pipeline. The program partners with businesses, educators, students, and their parents to build a workforce pipeline of the future. It works by combining high school curriculum and technology training with the essential on-the-job trainings required by the businesses. The program has thus far produced over 28,000 apprentices since 2007, with 965 registered programs (with Department of Labor) and 211 youth apprenticeship programs. As of 2017, 158 companies had a youth apprenticeship program with corporations such as Schaeffler Group USA and Greenfield Industries. The program helps companies gain access to more productive employees and fill key jobs involving new technologies.[28]

# Final thoughts

AS THE JOBS and economic situation in US manufacturing continue to unfold in the coming months, manufacturers should continue to address their present needs for finding qualified talent to ensure sustained workforce engagement. In addition, moving down the future path toward broader, industrywide approaches to closing the skills gap are fundamental to offset the expected shortfalls in skilled workers the coming decade may bring. Along with the approaches suggested above, industry leaders should explore ways to provide exposure to robotics, automation, and computer programming to primary school students. While companies often focus on middle and high school, engaging primary school students can be important to building the foundational skills and abilities needed to succeed in programs in the secondary grades.

Additionally, manufacturers should also work on changing workforce perceptions in manufacturing. Deloitte and The Manufacturing Institute's most recent *US Public Opinion of Manufacturing* study

reveals a gap between American people's support of manufacturing and their interest in pursuing long-term manufacturing careers.[29] To overcome this, the industry should continue building awareness and promoting manufacturing as an industry that has safe working conditions and can provide long-term career progression with competitive pay. Working through these approaches while strengthening the internal human capital strategy can position manufacturers for successful outcomes in the future of work in manufacturing.

# Endnotes


1. Deloitte analysis; Oxford Global Economics Model.
2. National Association of Manufacturers, "Top 20 facts about manufacturing," accessed October 17, 2018.
3. National Association of Manufacturers, *NAM manufacturers' outlook survey, third quarter 2018*, October 5, 2018.
4. Deloitte analysis based on Bureau of Labor Statistics data.
5. Bureau of Labor Statistics, "Job openings levels and rates by industry and region, seasonally adjusted," news release, accessed October 17, 2018.
6. Deloitte and The Manufacturing Institute skills gap and future of work in manufacturing study.
7. Ibid.
8. Ibid.
9. Craig Giffi et al., *The skills gap in U.S. manufacturing: 2015 and beyond*, Deloitte, 2015.
10. Deloitte and The Manufacturing Institute skills research initiative.
11. Tim Hanley et al., *The Industry 4.0 paradox*, Deloitte Insights, October 10, 2018.
12. Dr. Daniel Bachman and Rumki Majumdar, *United States economic forecast: 2nd quarter 2018*, Deloitte Insights, June 13, 2018.
13. A complete explanation of the input output methodology is available in Karen J. Horowitz and Mark A. Planting, *Concepts and methods of the US input-output accounts*, Bureau of Economic Analysis, April 2009.
14. Paul Wellener, Ben Dollar, and Heather Ashton Manolin, *The future of work in manufacturing: What will jobs look like in the digital era?*, Deloitte Insights, October 1, 2018.
15. Deloitte and The Manufacturing Institute skills research initiative.
16. Till Alexander Leopold, Vesselina Stefanova Ratcheva, and Saadia Zahidi, *The future of jobs report 2018*, World Economic Forum, accessed October 17, 2018.
17. Dimple Agarwal et al., *Introduction: The rise of the social enterprise—2018 global human capital trends*, Deloitte Insights, March 28, 2018.
18. Ibid.
19. Deloitte and The Manufacturing Institute skills research initiative.
20. Agarwal et al., *Introduction: The rise of the social enterprise—2018 global human capital trends*.
21. Dimple Agarwal et al., *The workforce ecosystem: Managing beyond the enterprise—2018 global human capital trends*," Deloitte Insights, March 28, 2018.
22. Leopold, Ratcheva, and Zahidi, *The future of jobs report 2018*.
23. Deloitte and The Manufacturing Institute skills research initiative.
24. Frank Newport, "Snapshot: Average American predicts retirement age of 66," Gallup News, May 10, 2018.

25. Agarwal et al., *Introduction: The rise of the social enterprise—2018 global human capital trends*.

26. Sheryl Smolkin, "Michelin, NIH see value in recruiting older workers," ebn, September 30, 2015.

27. Business Roundtable, *Work in progress: How CEOs are helping to close America's skills gap*, June 2017.

28. Apprenticeship Carolina, "By the numbers," accessed October 24, 2018; Apprenticeship Carolina, "Youth apprenticeships," accessed October 24, 2018.

29. Craig Giffi, Michelle Drew Rodriguez, and Sandeepan Mondal, *2017 US perception of the manufacturing industry: Manufacturing matters to the American public*, Deloitte, accessed October 17, 2018.

# About the authors

**CRAIG GIFFI** is vice chairman and national automotive industry leader for Deloitte USA, and the managing principal of Deloitte Insights. Giffi has primary responsibility for Deloitte's activities as a member of the Council on Competitiveness working with industry CEOs, university presidents, and labor leaders to shape the debate on competitiveness.

**PAUL WELLENER** is a vice chairman with Deloitte LLP and the leader of the US Industrial Products & Construction practice with Deloitte Consulting LLP. He has more than three decades of experience in the industrial products and automotive sectors, and drives key sector/industry initiatives to help companies adapt to an environment of rapid change and uncertainty.

**BEN DOLLAR** is a principal in the Global Supply Chain practice of Deloitte Consulting LLP. He focuses on organization design, talent management, and process improvement in manufacturing companies. Dollar has helped some of Deloitte's largest defense, automotive, and industrial products manufacturing clients achieve tangible benefits through organization design, process adoption, and human capital management.

**HEATHER ASHTON MANOLIAN** is the industrial manufacturing research leader with the Deloitte Center for Energy Solutions, and has delivered compelling insights on major enterprise business and technology trends for more than 20 years. Her expertise includes developing thought leadership at the intersection of business and technology, and covering emerging technologies from cloud to blockchain and augmented reality.

**LUKE MONCK** is a senior manager in Deloitte's Manufacturing practice with a background in human capital. He has over 15 years of experience leading large-scale organizational transformation initiatives for Fortune 100 companies. He supports his clients in responding to the digital revolution in manufacturing and brings them solutions to address the future of work in their organizations.

**CHAD MOUTRAY** is the chief economist for the National Association of Manufacturers (NAM), where he serves as the economic forecaster and spokesperson on economic issues. He is based in Washington, DC.

# About The Manufacturing Institute

The Manufacturing Institute is the social impact arm of the National Association of Manufacturers. The Manufacturing Institute drives programs and research to promote modern manufacturing and jump-start new approaches to growing manufacturing talent.

# Acknowledgments

The authors would like to recognize the exceptional work of the following individuals for their roles as sponsors, project managers, editors, researchers, and contributors: **Danny Bachman**, **Aijaz Hussain**, **Ankit Mittal**, **Kruttika Dwivedi**, **Sandeepan Mondal**, **Srinivasarao Oguri**, **Robert Libbey**, **Anisha Sharma**, **Rene Stranghoner**, **Mary Everette Cann**, **Lancy Jiang**, and **Rithu Thomas**.

# Contacts

**Paul Wellener**
Vice chairman, US Industrial Products and Construction leader
Deloitte Consulting LLP
+1 216 589 1300
pwellener@deloitte.com

**Benjamin Dollar**
Principal
Deloitte Consulting LLP
+1 617 852 9877
bdollar@deloitte.com

**Seema Pajula**
Vice chairman, US Industries & Insights leader
Deloitte & Touche LLP
+1 312 486 1662
spajula@deloitte.com

**Luke Monck**
Senior manager
Deloitte Consulting LLP
+1 571 512 1617
lmonck@deloitte.com

Deloitte.
Insights

Sign up for Deloitte Insights updates at www.deloitte.com/insights.

Follow @DeloitteInsight

**Deloitte Insights contributors**

**Editorial:** Rithu Thomas, Rupesh Bhat, Abrar Khan, and Preetha Devan

**Creative:** Emily Moreano and Anoop R

**Promotion:** Hannah Rapp and Nikita Garia

**Cover artwork:** Lucie Rice

**About Deloitte Insights**

Deloitte Insights publishes original articles, reports and periodicals that provide insights for businesses, the public sector and NGOs. Our goal is to draw upon research and experience from throughout our professional services organization, and that of coauthors in academia and business, to advance the conversation on a broad spectrum of topics of interest to executives and government leaders.

Deloitte Insights is an imprint of Deloitte Development LLC.

**About this publication**

This publication contains general information only, and none of Deloitte Touche Tohmatsu Limited, its member firms, or its and their affiliates are, by means of this publication, rendering accounting, business, financial, investment, legal, tax, or other professional advice or services. This publication is not a substitute for such professional advice or services, nor should it be used as a basis for any decision or action that may affect your finances or your business. Before making any decision or taking any action that may affect your finances or your business, you should consult a qualified professional adviser.

None of Deloitte Touche Tohmatsu Limited, its member firms, or its and their respective affiliates shall be responsible for any loss whatsoever sustained by any person who relies on this publication.

**About Deloitte**

Deloitte refers to one or more of Deloitte Touche Tohmatsu Limited, a UK private company limited by guarantee ("DTTL"), its network of member firms, and their related entities. DTTL and each of its member firms are legally separate and independent entities. DTTL (also referred to as "Deloitte Global") does not provide services to clients. In the United States, Deloitte refers to one or more of the US member firms of DTTL, their related entities that operate using the "Deloitte" name in the United States and their respective affiliates. Certain services may not be available to attest clients under the rules and regulations of public accounting. Please see www.deloitte.com/about to learn more about our global network of member firms.

Copyright © 2018 Deloitte Development LLC. All rights reserved.
Member of Deloitte Touche Tohmatsu Limited