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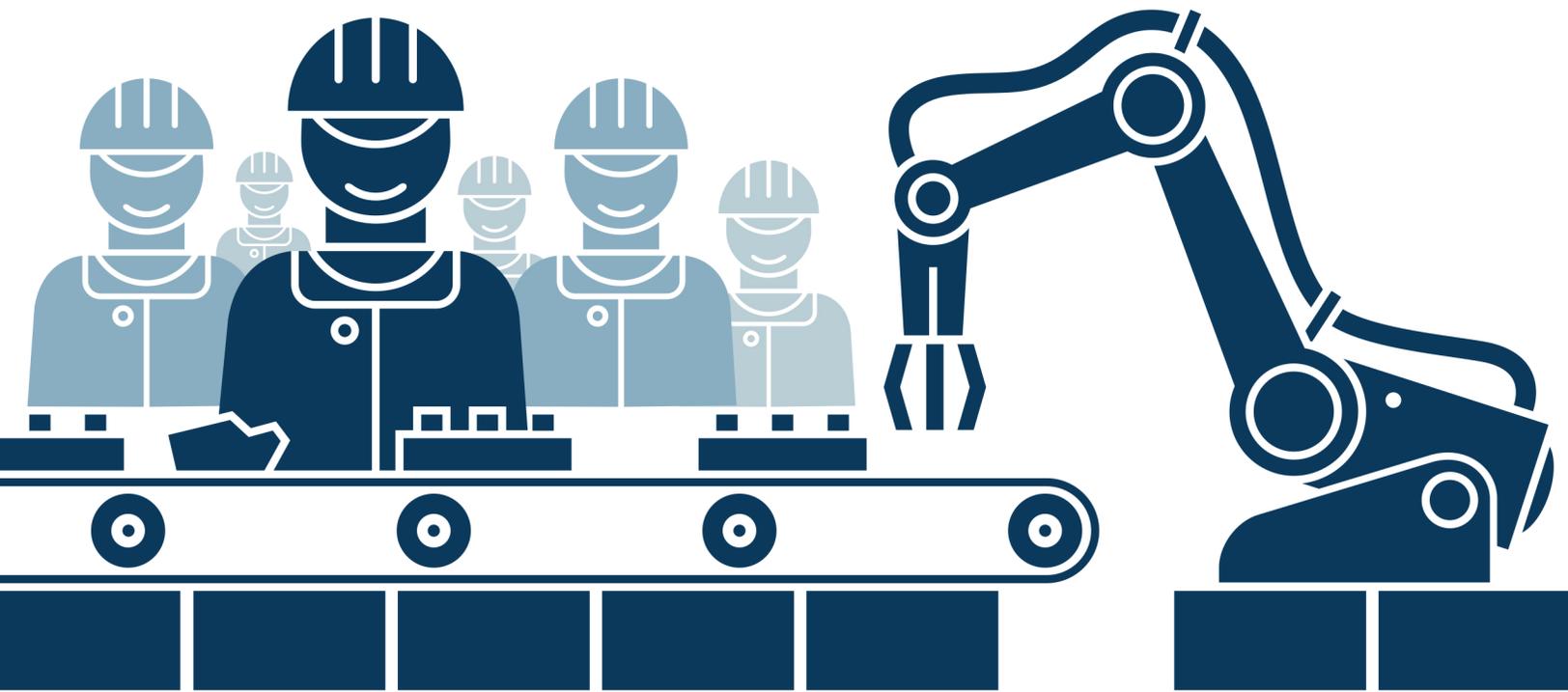
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WORK IN THE AUTOMATION AGE: SUSTAINABLE CAREERS TODAY AND INTO THE FUTURE





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Executive Summary

Each age in the Industrial Revolution has brought with it a wave of new opportunities and benefits. From steam to electricity to computers—and now to automation—society is transformed by technological advances that increase productivity and prosperity and broaden the availability of innovative goods and services. But more than anything, society is transformed by new, rewarding jobs that improve workers' health and safety and allow them to apply their innate creativity and problem-solving skills. In this paper, we cover some of the most relevant issues around jobs, training, and the inexorable advances in technology that help define the automation age.

- **More robots, more jobs.** As employers add automation technologies such as robots, job titles and tasks are changing, but the number of jobs continues to rise. New technologies allow companies to become more productive and create higher quality products in a safer environment for their employees. This allows them to be more competitive in the global marketplace and grow their business. We see this in the statistics: over the seven year period from 2010 to 2016, 136,748 robots were shipped to US customers—the most in any seven year period in the US robotics industry. In that same time period, manufacturing employment increased by 894,000 and the US unemployment rate decreased from 9.8% in 2010 to 4.7% in 2016. Specifically looking at two companies, Amazon had more than 45,000 employees when it introduced robots in 2014. While the company continues to add robots to its operations, it has grown to over 90,000 employees, with a drive to hire more than 100,000 new people by the end of 2018. Similarly, General Motors grew from 80,000 US employees in 2012 to 105,000 in 2016, while increasing the number of new US robot applications by about 10,000. We see similar results from multi-national companies with thousands of employees, to small manufacturing companies.
- **The skills gap and its impact.** Skilled workers are key to companies' success and countries' economic development. Employers rank the availability of highly skilled workers who facilitate a shift toward innovation and advanced manufacturing as the most critical driver of global competitiveness. But studies show an increasing skills gap with as many as two million jobs going unfilled in the manufacturing industry alone in the next decade. Fully 80% of manufacturers report a shortage of qualified applicants for skilled production positions, and the shortage could cost US manufacturers 11% of their annual earnings.

“CEOs and manufacturing executives around the world identify talent-driven innovation as the number one determinant of competitiveness.”¹

- **Changing job titles reflect changing tasks.** In the automation age, as in the computer age before it, job titles shift to reflect the impact of technology. A recent study concluded that occupations that have 10% more new job titles grow 5% faster. Just as we saw the rise of entire industries around previously unheard-of job titles in cloud services, mobile apps, social media, and more, we're seeing similar shifts in the automation age. As lower-level tasks are automated with advanced technologies such as robots, new job titles and industries arise across nearly every economic sector.
- **Supply and demand and wages.** In the manufacturing industry, which is the largest user of automation today, the skills gap is driving up what are already strong wages and benefits, well over the US average. In 2015, manufacturing workers earned \$81,289 including pay and benefits compared to \$63,830 for the average worker in all nonfarm industries. And 92% of manufacturing workers were eligible for health insurance benefits. Despite that, manufacturing executives reported an average of 94 days to recruit engineering and research employees and 70 days to recruit skilled production workers.
- **Bridging the skills gap with innovative training approaches.** Automation age jobs range from well-paying, entry-level and blue-collar positions through engineers and scientists. Stable automation-age manufacturing jobs can start at \$20 per hour with just a high school diploma, a few months of automation training, and professional certification. Employers, vocational schools, and universities are offering innovative training approaches that give workers alternatives to the traditional (and expensive) high-school-to-college-to-job route. And employers such as GM are revitalizing apprenticeships, recognizing the significant advantage those programs offer.

Technological Advances Transform Job Requirements

As technology advances through each industrial age, jobs—and job titles—have transitioned to reflect the new skills required. Some changes may be evolutionary, as existing workers adapt to the labor-saving capabilities of new technologies. Other changes are revolutionary, leading to brand new industries and previously non-existent jobs. These jobs and their requirements are difficult to anticipate as they arise from human ingenuity that leads to unexpected ways to implement rapid technology advances. Even two decades ago, few could have anticipated the dramatic numbers of jobs related to cell phones, mobile apps, social media, Internet providers, and cloud based services—or the specific skills needed for those segments to succeed. Similarly, tasks that can be automated with advanced technologies such as robots are giving rise to new careers and industries across the spectrum of human endeavors, from healthcare to transportation, and hospitality to manufacturing.

The Skills Gap in Manufacturing

The manufacturing industry is an early adopter and uses the largest segment of automation technologies. As a result, it has become a harbinger of the skills gap that threatens to slow productivity and growth in automated industries.

The most recent study by Deloitte and the Manufacturing Institute describes nearly 3.5 million manufacturing jobs that will be needed in the next decade. Two million of these jobs are expected to go unfilled due to the skills gap, with 80% of manufacturers reporting a moderate or severe shortage of qualified applicants for skilled production positions.² US manufacturers could lose 11% of annual earnings before interest, tax, depreciation, and amortization (EBITDA) or \$3,000 per existing employee due to the talent shortage.

Percent of executives who claim the skills gap impacts their ability to:³

82% Meet customer demand

78% Implement new technologies and increase productivity

69% Provide effective customer service

62% Innovate and develop new products

48% Expand internationally

The challenge has always been to ensure that the skills of human workers evolve along with the technologies. But in the automation age, the widening skills gap threatens to slow companies' ability to create and adopt automation technologies. Today's workers, as well as those who will enter the workforce in the upcoming decades, must be better trained and prepared to work with automation. For those who are, the rewards are often better paying jobs, with significant benefits and opportunities for advancement.

Growth in New Job Titles, and the Law of Supply and Demand

In each decade since 1980, employment growth has been greater in occupations with more new job titles, according to a study by MIT economists.⁴ From 1980 to 2007, total US employment grew by 17.5%, with just over half (8.8%) of this growth coming from additional employment in occupations with new job titles. In 2000, for example, about 70% of the workers employed as computer software developers (an occupation employing one million people at the time) held new job titles. The study concluded that occupations that have 10% more new job titles at the beginning of the decade grow 5.1% faster during that 10 years.

We're seeing a similar trend in the automation age. In almost every industry segment, automation-age workers are being required to perform tasks using rapidly advancing technology, resulting in new jobs and job titles. While robot programmers, operators, and repair technicians have become more common in manufacturing, those job titles are now appearing in a range of newly automated industries, from healthcare to hospitality and retail. New job titles for traditional roles such as machinists, welders, coders, and technicians often incorporate the term "mechatronics" to reflect the need for technical training that includes systems design as well as mechanics and electronics. Other new and upcoming jobs required across industries include computer vision and machine algorithm designers; robotics, vision systems, and motion control engineers; industrial network integration engineers; cyber-security experts; predictive equipment analytics specialists; industrial safety experts; IoT and data analysts; and material movement controls engineers. And of course, automation equipment manufacturers and integrators need an ever-increasing number of robot designers and application developers as well as industrial, electrical, software, and mechanical engineers and technicians with specific expertise in PLC controls and mechatronics, networking, and human-robot interfaces.

With all of this growth, the rules of supply and demand are in play in today's automated workplaces. A recent study reveals that 80% of manufacturing executives are willing to pay more than the market rate to fill positions impacted by the skills gap; nevertheless, 60% of those positions remain unfilled.⁵ This is especially surprising given the wage and benefits advantages of manufacturing jobs. According

“Consistent with the 2010 and 2013 Global Manufacturing Competitiveness Index studies, manufacturers continue to rank talent as the most critical driver of global manufacturing competitiveness.”⁸

to data from the Bureau of Economic Analysis and Bureau of Labor Statistics, the average US manufacturing worker earned \$81,289 in 2015, including pay and benefits (compared to \$63,830 for the average worker in all nonfarm industries).⁶ According to the Kaiser Family Foundation, 92% of manufacturing employees were eligible for health insurance benefits in 2015, which is significantly higher than the 79% average for all firms. Despite that, manufacturing executives reported an average of 94 days to recruit engineering and research employees and an average of 70 days to recruit skilled production workers.⁷

Productivity and The Distinction Between Jobs and Tasks

Automation offers efficiencies that bolster new companies and technology advances, increasing productivity and generating profits that bring in additional investment—and jobs. We've seen this happen through every age of the Industrial Revolution, and there's no reason to believe that won't continue to be the case. A recent paper calculates that robotics has increased labor productivity by 0.35% annually.⁹ That's about the same amount attributed to the steam engine, described as a classic example of a 'general-purpose technology' that has a pervasive, longstanding impact across multiple, dissimilar industries. As we look at automation, we also need to look at multiple dissimilar industries that include but aren't limited to manufacturing.

Ongoing studies on the impact of automation (specifically robots) on jobs draw widely varying and often conflicting conclusions. These studies typically don't compare what potential job losses would have been without automation, however. When businesses are forced to shutter because they can't compete, the loss of jobs can be far-reaching, rippling throughout the supply chain, the community, and related businesses and services. But multiple studies continue to show no relationship between a country's use of robots and loss of manufacturing jobs,* and we continue to see unemployment falling with the growth of robot sales. Looking only at US manufacturing jobs post-recession, the number of employees has increased along with record robot shipments. According to US Bureau of Labor statistics, from January 2010 through January 2017, manufacturing jobs in the US grew from 11,460,000 to 12,354,000—an increase of 894,000 jobs.¹⁰

What is often left out of these studies is that the most important indicator of economic growth is productivity. Robert D. Atkinson, president of the Information Technology and Innovation Foundation (ITIF), recently released a statement about low productivity in the US based on data from the U.S. Bureau of Labor Statistics

Automation and the Generation Gap

Today's skills gap is exacerbated by an aging workforce. The Deloitte study estimates that of the 3.5 million manufacturing jobs expected in the next decade, 2.7 million openings will result from retirements and 700,000 due to business growth. Millennials are now the largest generation in the labor force and will make up three-quarters of the world's workforce by 2025. For Millennials, the most sought-after industry is technology,¹² and automation feeds many of this generation's expectations for advances that increase prosperity and broaden the availability of innovative goods and services.

By taking on low-value tasks, automation offers the professional empowerment, flexibility, and creative challenges that these workers demand, while providing opportunities for advancement and financial security. This connected and educated generation will also impact the future of automation. They are familiar with current and rapidly changing technologies and business models and bring an emphasis on mission and values that will impact how automation is designed and used across industries.

* Sources include multiple studies cited in this paper, as well as those cited in the 2015 A3 white paper "Robots Fuel the Next Wave of U.S. Productivity and Job Growth." Other sources include the "The Future of Automation" by Sam Korus and David Conway, analysts at ARK Investment Management LLC; The McKinsey Global Institute report "A Future that Works: Automation, Employment, and Productivity"; and James Bessen's report "How Computer Automation Affects Occupations: Technology, Jobs, and Skills." Additional data comes from RIA and the Bureau of Labor Statistics.

(BLS). Atkinson said, “Economists all agree that raising productivity is the key to improving people’s living standards, yet to the extent it comes up at all, it is incorrectly portrayed as a boogeyman that kills jobs and exacerbates inequality.” Atkinson goes on to describe a need for a strategy that provides “...greater support for research and development for better tools of production, and focused follow-through to ensure firms adopt them more rapidly.”¹¹ Automation provides those tools.

While robots don’t cause net job losses, however, they do change the type of work and the skills required, driving new jobs and shifting existing jobs toward higher-value tasks. This distinction between jobs and tasks is critical.

David Autor, professor of economics at MIT, states that automating a subset of tasks increases the economic value of the remaining tasks.¹³ When ATMs became widely deployed, for example, the number of tellers per bank branch initially fell by about a third. Banks quickly discovered, however, that ATMs made it cheaper to open new branches, and the number of bank branches increased by about 40% in the same time period, with a net result of more branches and more bank employees. Since routine cash-handling tasks were managed by technology, employees took on more cognitively demanding jobs in relationship banking and investment and credit services. More jobs, with different titles, and higher value.

Steve Cousins, CEO of Savioke, a supplier of delivery robots for hospitality and other industries, has also seen this change—and it’s fundamental to the success of his fast-growing company. Within any given job there are numerous tasks, some of which are mundane and relatively low-value to the organization. By allowing a robot to perform those mundane tasks, the human worker’s job becomes focused on higher-value tasks that ultimately increase companies’ productivity. That increase in productivity leads to profits that can be reinvested into new or expanded business opportunities, which often require additional employees—a situation that some of Savioke’s hotel customers have experienced.

At Amazon, innovation means continuously looking for new ways to fuel the fast delivery and great Prime experience that its customers love. One of the ways the company innovates on behalf of its customers is through automation across its Customer Fulfillment network. Automation within Amazon operations works collaboratively alongside full-time employees to make jobs more efficient. In 20 fulfillment centers across the US, Amazon Robotics drive units pick up entire shelves of products and bring them to employees who are located at ergonomic work stations. With the help of Amazon Robotics, what used to take hours now takes minutes. As a result, skilled employees are able to focus on more sophisticated tasks. Associates have opportunities to move into roles as innovations process assistants, for instance, testing new technologies developed for Amazon fulfillment centers and working with engineers and operations managers to train associates.

Overall, the company continues to see significant job creation as it automates. When Amazon Robotics was deployed in 2014, the company had more than 45,000 full-

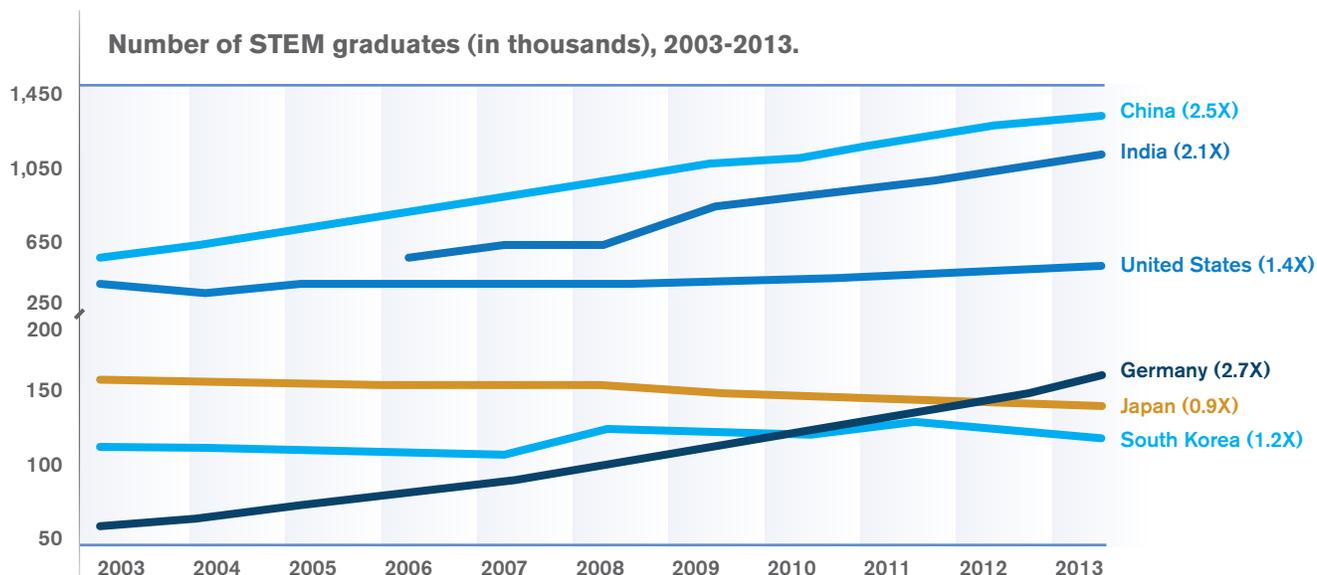
“...Innovation itself is the inventor of new forms of work.”¹⁴

time employees. Today, there are more than 90,000 full-time employees across its US Customer Fulfillment network, with a drive to hire more than 100,000 new, full-time employees across the company in the coming months. The new positions require a range of experience, education, and skill levels, from engineers and software developers to entry-level positions with on-the-job training.

No industry has adopted automation as extensively as the automotive industry. At General Motors, Industry 4.0—which encompasses automation, sensors, Internet of Things connectivity, and data analytics to drive productivity and innovation—is the mantra for continued profitability. During its recent period of increased profitability from 2012 to 2016, GM grew from 80,000 US employees to 105,000, while increasing the number of new US robot applications by approximately 10,000. The rise in manufacturing jobs is driven by product demand, but other areas of rising employment include areas such as IT insourcing and positions in advanced technologies such as future vehicles.

Bridging the Skills Gap: How Do We Get There from Here?

The range of opportunity for jobs in the automation age is huge—and promising. Entry-level, automation-age manufacturing jobs can start at \$20 per hour with just a high school diploma and a few months of training and professional certification. The jobs spectrum extends through traditional roles in marketing, sales, and management, through a full range of engineers and scientists.



Note: (...) figures in parentheses indicate the amount by which the number of STEM graduates have increased since 2003. India's STEM graduate figures have been extrapolated from 2010 data.

Source: Deloitte analysis based on data from OECD; National Bureau of Statistics of China; and University Grants Commission, India.¹⁵

While technical and computer skills are at the forefront of employers' requirements, that gap is closely followed by “a lack of problem-solving skills, basic technical training, and math skills... Overall, less than half of the executives surveyed in the Deloitte study indicate their employees have sufficient basic employability skills (attendance, timeliness, etc.) and the ability to work well in a team environment.”¹⁶ These statements were reinforced by our interviews with A3 members, who consistently pointed to the compelling need for employees with proficiencies and dedication to problem-solving, work ethic, lifelong learning, networking and mentorship, teamwork, and people skills.

Bridging the skills gap presents a significant challenge that requires efforts from multiple stakeholders. Efforts are underway that include K-12 STEM initiatives, vocational and technical training programs, and evolving degree programs from community colleges and universities. Manufacturers and automation suppliers agree that ongoing STEM initiatives are critical to the industry's long-term ability to fill technical roles. The US has seen little growth in the number of STEM graduates, however, while other countries—especially China, India, and Germany—continue to make dramatic improvements.

Apprenticeships & On-the-Job Training

While important, STEM efforts alone are not enough. RAMTEC Career Center in Ohio is home to the largest, most comprehensive robotics education center in the US. The center provides hands-on automation training and certification for high school students and industry workers, using up-to-date equipment that matches what workers use in real-world situations.

Chuck Speelman, Superintendent of the Tri-Rivers Career Center Campus where RAMTEC is located, says that many four-year and some two-year institutions still don't have enough hands-on learning opportunities that incorporate real-world automation systems being used in industry. That means the learning curve is still significant for graduates entering the workplace. And those degree programs aren't ideal for all students.

“Most students and parents believe that the only way to be successful is to go to a four-year college right after high school,” says Speelman. “They don't understand or appreciate the many different pathways and options that exist within the automation and advanced manufacturing careers. We all agree that the basic high school education is not enough, but students need to be exposed and encouraged to know the other opportunities that exist.” Those include real-world, industry-recognized certificates and training opportunities that lead directly to well-paying careers.

This echoes statements from Rebecca Hartley, Chief Workforce Officer for the Advanced Robotics for Manufacturing (ARM) Institute. This is a national, public-

Manufacturing's Role in the Economy

Manufacturing's impact on the economy can't be overstated.¹⁷

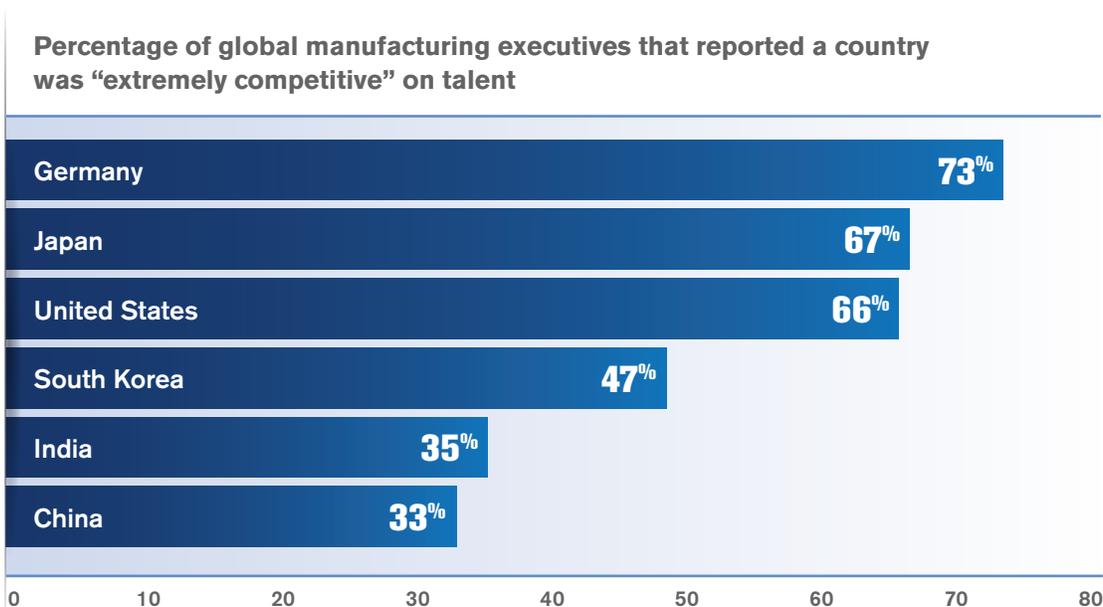
- **In 2015, US manufacturing generated more jobs than any other sector, with 12.3 million workers and indirectly supporting another 56.6 million jobs.**
- **On its own, the US manufacturing industry, valued at \$2.1 trillion USD in 2014, would be the ninth-largest economy in the world, with only eight other nations (including the US) ranking higher in terms of gross domestic product (GDP).**
- **For every dollar spent in manufacturing, \$1.81 is added to the general economy—the highest multiplier effect of any economic sector.**
- **Manufacturers in the US drive more innovation than any other sector, performing more than three-quarters of all private-sector research and development (R&D) in the country.**

private partnership designed to foster and grow the manufacturing ecosystem through robotics. Hartley sees opportunities for parallel tracks, in which workers can move between education and industry, gaining training and certifications and advancing their skills as they need them. This option is achieving traction as an alternative to the traditional (and expensive) high-school-to-college-to-job route that may not be ideal for all students.

Amazon offers an innovative benefit for its hourly employees called the Career Choice program to help workers gain the skills needed for today's most in-demand jobs, based on information from sources such as the US Bureau of Labor Statistics. The company pre-pays 95% of the cost of tuition for associates to go back to school and take courses related to in-demand fields—such as robotics, computer science, engineering, and IT—regardless of whether those skills are related to jobs at Amazon. Onsite classrooms allow college and technical classes to be taught inside fulfillment centers to make participation as easy as possible.

Traditional apprenticeships offer one of the best ways to build workforce skills through on-the-job training that provides current, real-world experience with the technologies that manufacturers depend on. Despite their advantages, apprenticeship programs that combine on-the-job learning with classroom education and mentorship declined 40% in the US between 2003 and 2013. During that time, job postings in STEM occupations outnumbered the unemployed by almost two-to-one from 2009-2012, while employment in STEM occupations is expected to grow by 17% through 2018.¹⁸

In contrast, Germany ranks number one in global manufacturing talent, which seems to reflect the success of its “dual system” of vocational training that focuses on mechatronics and boasts participation by approximately 60% of the country's



Source: Deloitte Touche Tohmatsu Limited and US Council on Competitiveness, 2016 Global Manufacturing Competitiveness Index.²⁰

youth. The program combines classroom instruction with work experience in one of 344 available trades. According to Deloitte, this is a model several countries are trying to emulate.¹⁹

The US automotive industry has historically been a strong advocate for apprenticeships, but the industry crisis and long economic downturn essentially resulted in the loss of a generation of new skilled tradespeople such as electricians, mechanics, and die makers. In 2017, for the first time since 2005, General Motors has eagerly indentured its first class of 200 apprentices to support its Global Manufacturing Systems (GMS) model for 2020. The model takes a highly efficient approach, with common technology platforms across the enterprise to drive ongoing productivity and profitability—which is also driving the need for a new approach to skilled trades.

GM worked closely with the Department of Labor to adapt apprenticeship training to GM's 2020 vision of technology needs, and partnered with the United Automobile Workers (UAW) union to roll out the new apprenticeship program. Apprentices now are evaluated not only for their technical skills, but also their ability to work in adaptable, team environments. And the new hybrid apprenticeship program is unique in letting apprentices apply experience and proficiencies against required training hours, allowing skilled apprentices to move into execution more quickly, and potentially cutting months or more than a year from the typically four-and-a-half-year program. The GMS model and agreement from the union also allow GM to assign apprentices into high-demand programs when they graduate, rather than depending on the accuracy of four-year forecasts of demand for electric vehicles versus trucks, for instance. Now the company can assign graduating apprentices where the need is at the time of graduation, and they all have a solid, common technology experience. The result: GM fills the skills gap with trained GM apprentices, and they get highly paid, rewarding jobs. GM is heavily engaged in continuing to grow its skilled trades apprentice program to support its ongoing business strategy.

Automation Drives Competitiveness and Creates Sustainable Careers

The automation age brings tremendous opportunities for companies to increase productivity, meet consumer demands for innovative, high-quality products, and drive the advancement of new industries. As companies grow and successfully compete through the use of automation technologies, they thrive and form the foundation for vibrant communities that boast a strong tax base, good schools, and a wide range of supporting industries.

But skilled workers are key to companies' success. For years, employers have ranked talent—defined as the quality and availability of highly skilled workers who facilitate a

shift towards innovation and advanced manufacturing strategies—as the most critical driver of global competitiveness.²¹ As new jobs arise, new approaches to education and training are also coming into play, offering attractive and viable options for new entries to the workforce as well as career-changers and underserved members, such as returning veterans, and raising diversity opportunities across industries. A3 members, partners, and colleagues are working hard to put programs in place across industries to develop and support this talent base and help bridge the skills gap. As with each stage in the industrial revolution, the automation age offers challenges, but also incredible opportunities.

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