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# Automation Isn't the Biggest Threat to US Factory Jobs

German factories have more robots than their US counterparts—so why are Americans four times more likely to leave their manufacturing jobs?

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APPLICATION: ROBOTICS

END USER: BIG COMPANY,  
SMALL COMPANY

SECTOR: AUTOMOTIVE,  
MANUFACTURING

TECHNOLOGY: ROBOTICS

**THE NUMBER OF** American workers who quit their jobs during the pandemic—over a fifth of the workforce—may constitute one of the largest American labor movements in recent history. Workers demanded higher pay and better conditions, spurred by rising inflation and the pandemic realization that employers expected them to risk their lives for low wages, mediocre benefits, and few protections from abusive customers—often while corporate stock prices soared. At the same time, automation has become cheaper and smarter than ever. Robot adoption hit record highs in 2021. This wasn't a surprise, given prior trends in robotics, but it was likely accelerated by pandemic-related worker shortages and Covid-19 safety requirements. Will robots automate away the jobs of entitled millennials who “don't want to work,” or could this technology actually improve workers' jobs and help firms attract more enthusiastic employees?

The answer depends on more than what's technologically feasible, including what actually happens when a factory installs a new robot or a cashier aisle is replaced by a self-checkout booth—and what future possibilities await displaced workers and their children. So far, we know the gains from automation have proved notoriously

unequal. A key component of 20th-century productivity growth came from replacing workers with technology, and economist Carl Benedikt Frey notes that American productivity grew by 400 percent from 1930 to 2000, while average leisure time only increased by 3 percent. (Since 1979, American labor productivity, or dollars created per worker, has increased eight times faster than workers' hourly compensation.) During this period, technological luxuries became necessities and new types of jobs flourished—while the workers' unions that used to ensure livable wages dissolved and less-educated workers fell further behind those with high school and college degrees. But the trend has differed across industrialized countries: From 1995 to 2013, America experienced a 1.3 percent gap between productivity growth and median wage growth, but in Germany the gap was only 0.2 percent.

Technology adoption will continue to increase, whether America can equitably distribute the technological benefits or not. So the question becomes, how much control do we actually have over automation? How much of this control is dependent on national or regional policies, and how much power might individual firms and workers have within their own workplaces? Is it inevitable that robots and artificial intelligence will take all of our jobs, and over what time frame? While some scholars believe that our fates are predetermined by the technologies themselves, emerging evidence indicates that we may have considerable influence over how such machines are employed within our factories and offices—if we can only figure out how to wield this power.

**WHILE 8 PERCENT** of German manufacturing workers left their jobs (voluntarily or involuntarily) between 1993 and 2009, 34 percent of US manufacturing workers left their jobs over the same period. Thanks to workplace bargaining and sectoral wage-setting, German manufacturing workers have better financial incentives to stay at

their jobs; The Conference Board reports that the average German manufacturing worker earned \$43.18 (plus \$8.88 in benefits) per hour in 2016, while the average American manufacturing worker earned \$39.03 with only \$3.66 in benefits. Overall, Germans across the economy with a “medium-skill” high school or vocational certificate earned \$24.31 per hour in 2016, while Americans with comparable education averaged \$14.55 per hour. Two case studies illustrate the differences between American and German approaches to manufacturing workers and automation, from policies to supply chains to worker training systems.

In a town on the outskirts of the Black Forest in Baden-Württemberg, Germany, complete with winding cobblestone streets and peaked red rooftops, there's a 220-person factory that's spent decades as a global leader in safety-critical fabricated metal equipment for sites such as highway tunnels, airports, and nuclear reactors. It's a wide, unassuming warehouse next to a few acres of golden mustard flowers. When I visited with my colleagues from the MIT Interactive Robotics Group and the Fraunhofer Institute for Manufacturing Engineering and Automation's Future Work Lab (part of the diverse German government-supported Fraunhofer network for industrial research and development), the senior factory manager informed us that his workers' attitudes, like the 14th-century church downtown, hadn't changed much in his 25-year tenure at the factory. Teenagers still entered the firm as apprentices in metal fabrication through Germany's dual work-study vocational system, and wages are high enough that most young people expected to stay at the factory and move up the ranks until retirement, earning a respectable living along the way. Smaller German manufacturers can also get government subsidies to help send their workers back to school to learn new skills that often equate to higher wages. This manager had worked closely with a nearby technical university to develop advanced welding certifications, and he was proud to rely on his

“welding family” of local firms, technology integrators, welding trade associations, and educational institutions for support with new technology and training.

Our research team also visited a 30-person factory in urban Ohio that makes fabricated metal products for the automotive industry, not far from the empty warehouses and shuttered office buildings of downtown. This factory owner, a grandson of the firm’s founder, complained about losing his unskilled, minimum-wage technicians to any nearby job willing to offer a better salary. “We’re like a training company for big companies,” he said. He had given up on finding workers with the relevant training and resigned himself to finding unskilled workers who could hopefully be trained on the job. Around 65 percent of his firm’s business used to go to one automotive supplier, which outsourced its metal fabrication to China in 2009, forcing the Ohio firm to shrink down to a third of its prior workforce.

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wages.

While the Baden-Württemberg factory commanded market share by selling specialized final products at premium prices, the Ohio factory made commodity components to sell to intermediaries, who then sold to powerful automotive firms. So the Ohio firm had to compete with low-wage, bulk producers in China, while the highly specialized German firm had few foreign or domestic competitors forcing it to shrink its skilled workforce or lower

Welding robots have replaced some of the workers' tasks in the two factories, but both are still actively hiring new people. The German firm's first robot, purchased in 2018, was a new "collaborative" welding arm (with a friendly user interface) designed to be operated by workers with welding expertise, rather than professional robot programmers who don't know the intricacies of welding. Training welders to operate the robot isn't a problem in Baden-Württemberg, where everyone who arrives as a new welder has a vocational degree representing at least two years of education and hands-on apprenticeship in welding, metal fabrication, and 3D modeling. Several of the firm's welders had already learned to operate the robot, assisted by prior trainings. And although the German firm manager was pleased to save labor costs, his main reason for the robot acquisition was to improve workers' health and safety and minimize boring, repetitive welding sequences—so he could continue to attract skilled young workers who would stick around. Another German factory we visited had recently acquired a robot to tend a machine during the night shift so fewer workers would have to work overtime or come in at night.

In contrast, the Ohio company had purchased nine traditional, noncollaborative robot welding cells in the 1990s (and none since then), but one of the robots was mothballed in a warehouse because the firm couldn't find enough skilled robot operators and its owner insisted the factory needed people more than robots. Unlike the German companies, most of the Ohio firms we interviewed would eagerly hire anyone who could pass their drug test, show up on time, and weld in a straight line—regardless of formal qualifications. Another American factory owner in our study bemoaned the lack of first-generation immigrants who are "great workers and they love overtime, unlike this generation of Americans who want work-life balance."

As the German example illustrates, robots can improve ergonomics and save workers from drudgery, and recent studies indicate that robot adoption can boost employment for small and midsize manufacturers by enhancing product quality, improving productivity, and allowing firms to branch into new product lines. Yet robots have also been known to have the opposite effect on workers—especially in larger factories with less-skilled workers, where extensive automation can break up jobs and leave workers with repetitive, hard-to-automate tasks, such as continuously loading the same item into the same machine. But a lack of robots may make firms more susceptible to being outbid by higher-tech rivals, potentially leading to even more widespread job loss in manufacturing.

**EVEN THOUGH NO** two companies install automation the same way, prevailing societal narratives tend toward the ill-fated destiny of a Greek tragedy, in which some engineer's first forays into robotics are guaranteed to doom workers around the world to obsolescence. This theory of "technological determinism" was most famously formulated by Marx and Engels during the industrial revolution: If factory owners didn't continue shrinking labor costs through technological advancement and/or exploitation, they would lose to competitors, and if workers weren't willing to work, they would starve. Such an unstable arrangement, heightened by a continuous trend toward automation, would purportedly precipitate global class warfare.

Today's economists predict less dire outcomes, although many tend to assume that technology is likewise predestined and that as soon as automation becomes cheaper than labor for the tasks that comprise a specific job, all rational businesses will immediately replace those workers with technology. Such deterministic arguments presume that companies around the world will converge upon the same automation strategies, regardless of differences across countries.

But evidence at the national scale indicates otherwise. Considering the many differences between nations, political scientists found that different countries actually pursue divergent “varieties of capitalism” that play to their unique strengths. Germany’s expertise and market domination in high-end manufacturing come from more than a century of dedicated policies and ecosystem-development initiatives, such as the Fraunhofer Institutes, including training collaborations with artisanal guilds, industrial research and development programs for firms of all sizes, and generous subsidies for equipment and training. In contrast, a team from MIT found in 2013 that American manufacturers were “home alone” in comparison to the rich support networks of their competitors in China and Europe—and the Ohio firm our team visited was no exception. The owner had attended meetings about Small Business Association stimulus spending in 2009 to advocate for training and better protections from predatory banks, but government administrators had nothing to offer, since he didn’t fit any of their minority-business-owner categories. He also served on the board of a local community college’s curriculum committee, but the college proved unable to productively collaborate on skills that would be relevant for his workplace.

So it seems the German firms will follow a path that favors well-educated workers and high-value precision manufacturing while American firms pursue strategies that favor rapid innovation, less-educated workers, and high workplace turnover.

While the Germans strengthened their industrial regime and renewed incentives to focus on their traditional manufacturing strengths, American politicians chose to give up on manufacturing and let states like Ohio languish in favor of regions with higher-growth businesses. In the 1990s, Germany declared Baden-Württemberg its “Showpiece State” because of its successful automotive industry and job growth—around the same time Ohio became part of the “Rust

Belt” of industrial decay.

One problem with American policy-makers ignoring manufacturing in favor of higher-tech sectors is the disproportionate economic impact on particular regions and their workers. As large firms outsource both workers and supply chains in favor of high-growth “core competencies” that satisfy their investors, these firms’ domestic suppliers, like the Ohio firm, lose crucial contracts. Firms with fewer than 500 employees make up the vast majority of the manufacturing sector and employ more than 5 million US workers, or 43 percent of the domestic manufacturing workforce. As a fraction of its GDP, the government of Germany spent 20 times more than the US on support programs for small and midsize manufacturers in 2011, and six and a half times more on “active labor policies” that improve job readiness, expand employment opportunities, and reskill displaced workers in 2017. Such policies are especially important for smaller firms that can’t afford their own training programs.

But regional policies are subject to change, and even neighboring firms may pursue very different strategies depending on worker availability, skill, technology subsidies, and business norms—not to mention where that company sits in the supply chain, and its value proposition. (Despite Germany’s reputation for high-tech manufacturing, 76 percent of German manufacturing companies with 50-249 employees and 90 percent of companies with 10-49 employees don't have any robots at all.) In today’s globalized world, manufacturing firms in industrialized countries face a choice between competing on cost or on quality and customization. To quote another Ohio factory owner, “we can’t compete with \$1/day jobs, so we need to compete with our heads.”

**SADLY, THE LACK** of American manufacturing policies, comprehensive vocational training, and other support programs

strongly encourages factories of all sizes to compete on cost. To transition from combustion engines to electric vehicles, Germany's Bosch launched a €2 billion plan to reskill its workers for equivalent or higher-paying jobs. Meanwhile, America's General Motors took advantage of the same technological shift to replace \$31/hour unionized workers in its plant with \$17/hour subsidiary workers doing similar tasks.

This low-wage strategy has been a trend among American auto manufacturers, with predictable consequences. One key to Toyota's success over American cars in the 1980s was the Japanese company's ability to engage workers across the assembly line in quality control and production improvements, but American factories were too highly automated and engaged in union-management struggles to follow suit. This American reliance on automation rather than skilled workers has persisted; in 2018, following a disastrous attempt to fully automate Tesla's Model 3 production line in California, Elon Musk admitted on Twitter, "Humans are underrated."

As economist David Autor (a member of our research team) told the New York Times, "Most people's fear of technology is really a fear of capitalism, what the markets will do with the technology." Even workers' fears around automation turn out to be highly dependent on welfare policies and the existence of retraining opportunities; 80 percent of Swedes in 2017 were positive about the prospects of AI and robots, while 72 percent of Americans were "worried." Luckily for smaller manufacturers, recent robot adoption has been proven to go hand in hand with job improvement and skills development—especially given today's global shortage of skilled manufacturing workers.

Manufacturing firms that hope to maintain global competitiveness will need workers with the requisite technical backgrounds who are

willing to engage with new technology, and hopefully stick around for long enough to knowledgeably contribute to factory improvements. As digital transformations across the economy automate repetitive tasks while requiring increased problem-solving, the need for better-trained and more engaged workers is likely to be similar across other sectors. But to meet these demands of the future, we'll need policies that help managers see their workers not as costs to be minimized and discarded, but as assets to be strengthened over time.

*This research was conducted in collaboration with Simon Schumacher, Lindsay Sanneman, Roland Hall, Suzanne Berger, and the MIT Work of the Future Ohio Research Team.*

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