

POLICY INSIGHTS

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Cobots as Workforce Partners: Overcoming Barriers Through Policy Opportunities

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ABSTRACT

Substitution of capital in the form of automation and robotics has displaced many American manufacturing workers, especially those without college degrees. However, this need not be the path forward. We argue that now is an opportune time for greater policy emphasis on collaborative robots, or “cobots,” which are designed to complement rather than replace manual labor while raising productivity. To realize this potential, policies must properly align incentives, support training, and address often overlooked issues such as monitoring and privacy. Through an interdisciplinary lens, we examine the current state of cobot deployment and describe how well-designed job tasks, paired with carefully integrated cobots, can preserve employment opportunities while improving ergonomics and enhancing productivity. Strategic policy measures aimed at redirecting investments can balance manufacturers’ needs while ensuring stable employment, higher wages, and safer workplaces. With informed and deliberate policy, the adoption of cobots can mark a new phase of technological progress while averting the costly dislocations that accompanied past automation and offshoring.

1 | Introduction

Manufacturers have increasingly turned to automation and robotics under pressure to boost productivity. The recent trajectory of technological change reflects what Schumpeter termed “creative destruction”: technology has raised productivity but also led to widespread layoffs, plant closings, and the loss of stable jobs for many blue-collar, non-college-educated workers (Autor et al. 2024; Acemoğlu and Restrepo 2022, 2024; Boustan et al. 2022; Restrepo 2023). While discourse around emerging technologies often emphasizes further worker displacement through robotics and artificial intelligence (AI) (Kingson 2023), some remain skeptical about the inevitability of displacement (Manjoo 2022; Capraro et al. 2024; Strain 2024). As new tariffs

would alter the relative costs of producing domestically versus abroad, US manufacturing becomes more attractive. But with labor costs remaining high—reflecting an older workforce and tighter labor supply—firms are likely to rely more heavily on capital, including robotics.

Our policy insight is that the rise of *collaborative* robotic technologies, or “cobots,” creates new space for forward-looking policy intervention—policies that not only recognize the potential of human–machine collaboration but also actively shape the conditions under which it can thrive. Cobots already account for a growing share of industrial robots and can raise productivity by augmenting manual labor rather than replacing it. Their rapid deployment underscores the need for timely,

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Figure 1 | Cobot application at Ford Motor Company. A cobot application at a Ford Motor Company's assembly plant in Cologne, Germany. In the application, the cobot carries a heavy, air-powered tool, which the worker positions during the installation of shock absorbers in Ford Fiesta model cars. (Copyright: Ford Media Center.)

human-complementary policy. Such policy requires both a clear understanding of cobot capabilities and an alignment of incentives so that the gains from new technology are broadly shared.

Unlike traditional industrial robots, which operate in isolation for worker safety, cobots are in fact designed and engineered to work safely alongside people and can be readily adapted for use across a variety of settings at relatively low cost with minimal changes to existing facilities and processes. They take on repetitive or physically straining tasks, allowing workers to focus on dexterous or decision-based tasks. Figure 1 illustrates such complementarity in an application at a Ford automotive assembly plant, where a cobot carries a heavy tool while the worker positions and supervises its use during shock absorber installation, reducing physical strain while raising productivity. Across many applications, specific manufacturing tasks, rather than entire jobs, can be automated and combined with human work in ways that are both safer and more efficient.

Technological advances in robotics, assisted by artificial intelligence, extend this potential by enhancing productivity without necessarily displacing jobs. As Autor (2024) and others have shown, productivity gains from automation can also increase the value of human labor. By automating undesirable tasks while preserving those requiring human expertise, the integration of cobots can reduce workplace injuries, extend career longevity, and increase overall labor productivity as workers adapt to new technologies (Moe and Rodgers 2024).

What policies would best support a “human-centered” transformation that averts the most disruptive consequences of automation we have seen in the past? A shift toward cobotics that improves worker and societal well-being will require policies based on an understanding of the current state of the technology, its limitations, and its design potential. Motivating these policies from an interdisciplinary perspective, we describe promising advancements and barriers in cobot deployment, then, consider-

ing the role of existing institutions and incentives, we propose forward-looking policy areas to align productivity growth with more stable and desirable jobs.

2 | The State of Cobots: Promise and Challenges

Cobots hold substantial promise for reshaping work, but realizing these gains depends on how they are designed and integrated. Advances in human–robot interaction have created opportunities for safer and more productive collaboration, yet challenges remain around worker safety, satisfaction, and distributional impact that policy must account for and can in some cases address.

2.1 | Design Advances and Worker Reception

Much of the recent progress in cobotics has focused on enabling productive interaction between humans and robots (Arora et al. 2021; Kildal et al. 2018; Mutlu and Forlizzi 2008; Pearce et al. 2018). New approaches to task allocation (e.g., Pearce et al. 2018) allow repetitive or physically straining tasks to be shifted to cobots while workers maintain oversight and decision-making roles. Studies demonstrate that these forms of task allocation can create “hybrid” human–robot teams that improve both productivity and ergonomics, particularly for tasks that are parallelizable, repetitive, or physically awkward. Such ergonomic gains are especially valuable for an aging blue-collar workforce, where physical strain becomes a growing constraint on continued employment (National Academies of Sciences, Engineering, and Medicine 2022).

Other advances involve end-user programming interfaces and teleoperation. End-user programming allows workers to plan automated tasks for cobots and intervene to make corrections when automation falls short (Hagenow et al. 2024), thereby enabling even imperfect cobots to be suitable for widespread adoption across firms. Evaluations of this approach in manufacturing tasks, such as sanding applications, show that this model of human–robot collaboration reduces fatigue compared to manual operation, improves quality related to full automation (Konstant et al. 2024), and allows workers to supervise multiple cobots simultaneously (Hagenow et al. 2023). Teleoperation, on the other hand, allows precise robot operation from a distance, making it possible to coordinate human and robot workers across distributed—and sometimes hazardous—worksites (Kim et al. 2024).

Worker acceptance of robots and cobots is an essential design and training barrier to overcome. Concerns about safety, job loss, and mistrust can hinder adoption, yet evidence shows that it is possible for carefully integrated cobots to *improve* worker satisfaction (Arora et al. 2021; Kildal et al. 2018; Grosse et al. 2023). Acceptance grows when workers perceive ergonomic benefits, gain ownership by programming or configuring cobots, or interact with cobots that provide social cues (Tausch et al. 2022; Nikolova et al. 2024; Paluch et al. 2022). In some field studies, workers even attribute human-like qualities to cobots, suggesting that design features influence not only productivity but also the social environment of a workplace (Saupé and Mutlu 2015).

These advances show that cobots can be more than just tools, becoming reliable partners in production when design emphasizes complementarity and worker experience.

2.2 | Worker Safety, Workload, and Satisfaction

The effects of technology on workers are not just limited to wages and employment but also job content, job quality, and economic stability (American Academy of Arts and Sciences 2023; Matthews et al. 2023). By taking on repetitive or physically demanding tasks, they reduce injuries and improve ergonomics. Indeed, research from the United States and Germany shows that robots already lower injury rates, and cobots are especially well suited to the many jobs where strain is high but full automation is not feasible (Gihleb et al. 2022; Lin et al. 2024). By reducing ergonomic risks, cobots could even indirectly mitigate opioid use disorder, which is closely linked to work-related pain and injury (Shaw et al. 2020; Asfaw and Boden 2020). Hence, meaningful improvements in workplace conditions can improve, and save, lives.

At the same time, the integration of cobots does not guarantee improvement. Poorly designed integration can intensify workloads, accelerate the pace of work, and reduce autonomy (Gutelius and Theodore 2019; Lager et al. 2021; Zhu and Kanjanamekanant 2023), introducing what some call “digital Taylorism” (Howard 2022). These conditions raise stress, injury risk, and turnover. But the situation is not hopeless, as analyses reveal that for some jobs, physical and mental workloads decrease, while for others, they increase after human–cobot task allocation optimizes for productivity (Pearce et al. 2018; Liu et al. 2024).

Monitoring technologies are often part of cobot systems, which adds another layer of complexity. Smart systems that track worker and cobot activity can enhance safety and coordination, but also raise concerns about surveillance and productivity pressure. Many workers dislike monitoring due to privacy risks and mistrust, especially if data could be used for discipline or discrimination (Ball et al. 2021; U.S. Government Accountability Office 2024; West 2021). Yet in other industries, such as trucking, driver monitoring is sometimes welcomed when it clearly improves safety and reduces accidents (Ghazizadeh et al. 2012; Huang et al. 2005). In law enforcement, body-worn cameras may *encourage* coercive police behavior when they are used to assess officer performance but *discourage* when used for procedural review (Kang 2023). This variability suggests that design and regulation will determine whether monitoring strengthens or undermines worker trust.

Finally, cobot impacts will be uneven. Work by Lin et al. (2024) shows a wide potential impact of cobots across industries, demographics, and geography. The intensity of geographic impact is reproduced in Figure 2, and shows an uneven distribution across states nationally. The occupations most likely to see cobot integration are often physically demanding and employ younger, lower-income workers (lower panel of Figure 2). At the same time, cobots certainly have the potential to expand opportunities for older or physically limited workers by shifting jobs away

from many strenuous tasks—a welcome development given our aging demographics.

3 | Policy Priorities for Human-Centered Cobotics

Cobot deployment need not follow the path of past automation, and deliberate, human-centered technology policy can steer adoption away from displacement and toward realizing cobots’ broader promise. The current combination of advancing technology, high labor costs, and shifting trade conditions makes this the right time to act. Institutional arrangements, corporate incentives, and trade policy all shape how new technologies are adopted, often in ways that prioritize short-term profit over long-term job quality. Without intervention, firms may deploy cobots in ways that intensify workloads or displace workers rather than complement them.

Institutional and policy context. Several institutions and policy structures already influence cobot adoption. As Blanchflower and Bryson (2024) show, unions have historically been instrumental in improving wages and working conditions and could continue to play a role in ensuring that new technology enhances rather than undermines such gains. While the anticipated increase in automation has been shown to weaken bargaining in Leduc and Liu (2024), renewed organizing in industries such as automotive demonstrates that unions can play a constructive role in promoting complementary approaches to technology. Worker voice more broadly remains significant, reflecting growing interest in for a say in the integration of new technologies that are increasingly reshaping working conditions.

Corporate tax structures also matter. Current U.S. policy taxes capital income at lower rates than labor, incentivizing automation even when human-complementary technologies might be more socially beneficial (Suarez-Surrato 2021). If estimates of capital’s responsiveness to taxation are overstated, the preferential treatment of automating capital cannot be justified (Acemoglu et al. 2020). Shifting tax incentives toward worker-augmenting technologies like cobots would help correct this imbalance.

Trade and tariff policy additionally shape the context for cobot deployment. Free trade agreements delivered broad consumer benefits but the costs were concentrated among manufacturing communities. Most Americans favor free trade agreements but also think that more has been lost than gained through increased trade (Pew Research Center 2024) and consider tariffs acceptable under certain circumstances (Harvard CAPS/Harris Poll 2025). Recent industrial policy, including the CHIPS and Infrastructure Acts, has encouraged new domestic manufacturing investment (Joint Economic Committee 2024; Ross and Muro 2024). With higher costs leading to decreases in imports from China, there has been a significant increase in domestic manufacturing structure investment, shown in Figure 3, adapted from Dunn and Leibovici (2024). In this environment, cobots are especially appealing, as they can help offset high labor costs while preserving and upgrading employment opportunities.

Against this backdrop, we propose five policy priorities that would move ongoing cobot adoption in alignment with broader economic and social goals.

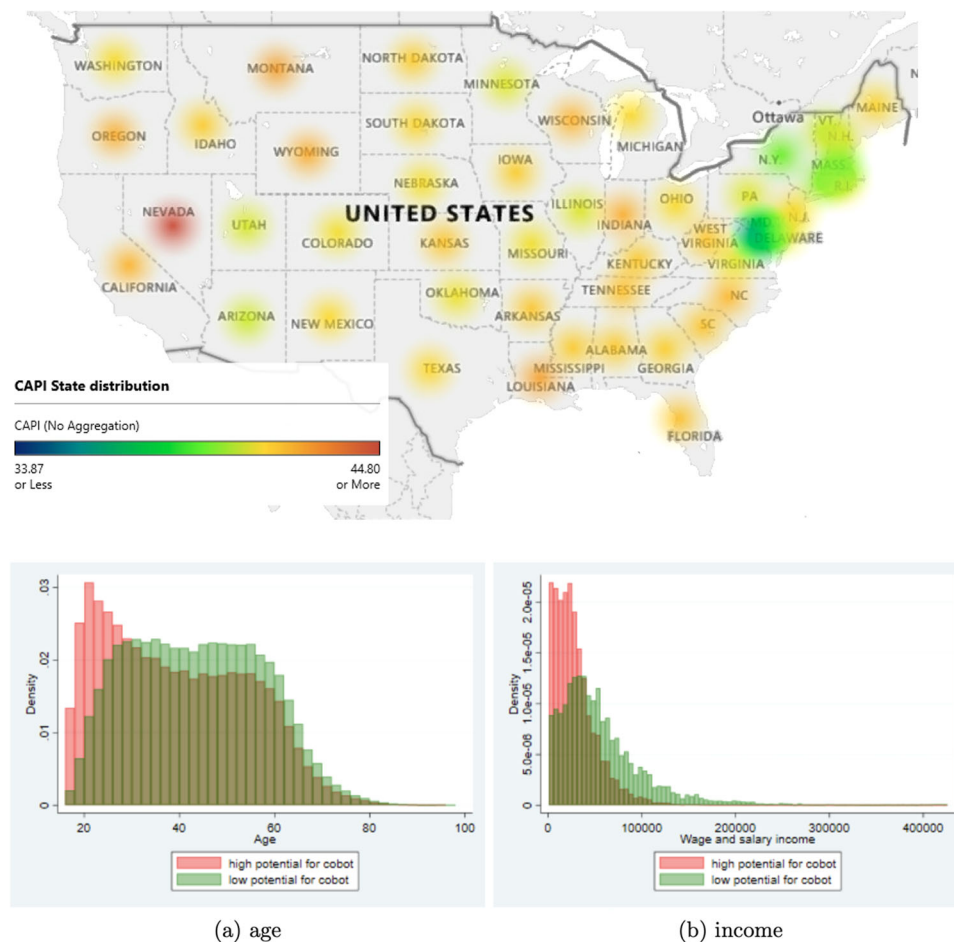


Figure 2 | Geography, age, and income among workers in cobot-exposed occupations. Top: Geographic distribution of cobot-exposed work. Bottom: (a) age and (b) income distributions for people in jobs with high- and low-cobot exposure. *Source:* Lin et al. (2024).



Figure 3 | Total manufacturing construction investment. Surge in real total manufacturing construction investment after the passage of the CHIPS Act and IRA. Adapted from Joint Economic Committee (2024); data source: FRED Total Manufacturing Construction Spending, monthly at a seasonally adjusted, annualized rate using FRED Price Index of Materials and Components for Construction.

3.1 | Strategic Investments in Human Capital

Strategic investments in formal postsecondary training and education, coupled with clear pathways to employment, would minimize displacement and promote recovery. U.S. labor markets are very flexible but do not often facilitate connections that both help prepare people for jobs and then link them to these jobs. Sectoral technical training, or “career and technical education” (CTE), can be accomplished through existing and expanded

collaborations between community colleges and employers to provide the necessary skills. Additionally, apprenticeships and on-the-job learning can also contribute (Katz et al. 2022) and be encouraged through tax incentives for firms that provide training in working with cobots and other technologies that enhance human labor. By adopting these strategies, such technologies would be more attractive relative to those designed to displace human labor, ensuring a swifter recovery for and minimization of displaced workers (Furman 2024). The U.S. Trade Adjustment

Assistance (TAA) program, which has helped provide wage insurance for workers adversely affected by trade, could be used also to compensate workers displaced by technology (Hyman et al. 2024). While the effectiveness of TAA has been mixed (Schochet et al. 2012), lessons from it can inform the design of programs that anticipate—rather than respond to—potential disruptions, relying on estimates of robotics exposure (Felten et al. 2021; Lin et al. 2024). Such programs and policies are widely practiced in Europe and offer models that could be adopted (Kuziemko et al. 2023).

3.2 | Supporting Human-Centered Cobot Research and Development

Tasks where cobots are carefully integrated to augment worker capabilities have the potential to mitigate physical strain by performing repetitive and physically demanding tasks and reduce direct costs associated with worker injuries and lost time, as well as reducing indirect costs associated with reassignments, insurance, and work dissatisfaction. While this is clearly valuable for workers, employers, and society broadly, the private costs of development are concentrated while the social benefits are diffuse, and so many technologies come from research focused on more narrowly defined objectives. Increased public funding for human-complementary technology research as well as technology development and commercialization, recognizing that this is not currently a private sector priority, should be better supported to optimize robotics for all (Kim et al. 2024). Without such support, we risk underinvesting in cobot technologies that yield broad benefits. Innovation in cobotics is currently driven by internal research and development divisions within and investments by large companies (Allgor et al. 2023), and in addition to technological advantage, tax incentives for companies, in exchange with public sharing of advancements, can facilitate industry-driven innovation. As it is now, because not all benefits are internalized, even negligible costs can discourage investment in design approaches that would yield broad societal benefits. Human-centered design and research that takes an integrated, cross-disciplinary perspective on workplace technologies like cobots should be advanced within existing research and funding structures.

3.3 | Place-Based Investment Strategies

Policies promoting the integration of human-centered technology should expand on or redirect recent targeted programs, such as the 2022 CHIPS and Science Act's regional tech hubs program and the 2017 Tax Cuts and Jobs Act's Opportunity Zones. As larger companies seek to reduce supply chain risks by investing closer to their customers, these programs have further encouraged revitalization in areas affected by disinvestment due to trade and technological changes (Muro et al. 2022). Much of this new investment targets communities that suffered the worst impacts of plant closures in recent decades, some of which are gaining a disproportionate share of new investment and job creation (Juhász et al. 2024), with both notable successes and failures (Goodman 2024; Goldstein 2024; Benzow and O'Brien 2024). By aligning place-based investment with training and cobot integration, communities can capture the benefits of reshoring

while avoiding a repeat of past displacements. These investments can build on the valuable domain experience of workers displaced by automation and shifting trade practices, ensuring that their knowledge continues to inform an increasingly automated economy.

3.4 | Worker Input, Safety, and Privacy

Policies that facilitate the integration of cobots in the workplace should seek to promote worker input, safety, and privacy, while avoiding unsustainable cost increases or discouraging full automation. This goal can be achieved by encouraging collaboration on productivity-linked agreements. A collaborative approach, as demonstrated by Germany's industrial unions, enables companies to embrace and adapt to technological advancements while maintaining competitiveness by improving both productivity and wages (Bailey 2022). Actively promoting collaborative investment, however, also requires policies that would align the training needs of people and employers. Such policies should include more tangible incentives for investment in human capital to complement human-centered cobot technologies. While unions can advocate for training and upskilling programs that enhance labor value and reduce the risk of automation-driven displacement, such initiatives are not always in employers' immediate interests or financially viable. Firms could be incentivized to provide these programs through tax deductions, alongside training initiatives coordinated through the Workforce Innovation and Opportunity Act (WIOA).

Additionally, federal agencies should strengthen occupational safety guidelines and oversight for human-cobot environments. Because the Occupational Safety and Health Administration (OSHA) currently addresses ergonomics hazards only under the General Duty Clause, new frameworks for reporting and hazard monitoring are needed to better identify and mitigate risks of physical stress and strain. Such frameworks could draw on scientific expertise from the National Academies and from the CDC National Institute for Occupational Safety and Health (NIOSH) or its successor public health research entity, complemented by research funding from the National Science Foundation and National Institutes of Health. Building a stronger scientific basis for occupational ergonomics would complement employer-level initiatives to deploy AI-driven sensing and computer-vision technologies that detect hazards efficiently and reduce the burden on employers. These efforts could incorporate incentives to reduce injuries by increasing employer penalties for preventable incidents and rewarding firms that demonstrate measurable safety improvements, while maintaining worker well-being and privacy through noninvasive monitoring tools.

3.5 | Tax Policy Reform

The longstanding tax preference for capital income in the United States and in other advanced economies continues to favor investments toward automation, reinforcing the bias toward labor-replacing capital and a reduced labor share of national income (Hourani et al. 2023; Karabarbounis 2024). Along with Capraro et al. (2024), we would argue for equalizing the effective marginal tax rates between labor and capital and incentivizing

worker-augmenting technologies. In doing so, the existing price distortions would diminish, and more investment would be directed towards enhancing human labor—including technologies such as cobots—and away from technologies that displace or automate human labor.

4 | Conclusion

Cobots hold significant promise for enhancing productivity through collaboration with human workers rather than displacement. This moment presents an opportunity for policy to guide deployment, drawing lessons from past experiences with automation and offshoring. Understanding and anticipating barriers—ranging from safety and monitoring to uneven workforce impacts—is essential to ensure cobots enhance job quality as well as wages and employment.

Cobot adoption hinges not only on engineering capabilities and design but also on institutional and policy choices. Optimal task allocation that favors ergonomics along with productivity, effective end-user interfaces, and teleoperation capabilities show how cobots can reduce strain, extend careers, and raise productivity. Yet, ultimately, successful cobot integration requires creating an environment in which the interests of workers and employers are more aligned to balance immediate cost savings with labor-augmenting, long-term benefits.

The United States has an opportunity to shift the trajectory of technological change away from labor *replacement* and toward labor *enhancement*. By making proactive investments and policy adjustments now, human-centered cobotics can deliver productivity growth that strengthens, rather than undermines, the social and economic foundations of work.

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Data Availability Statement

Data sharing is not applicable to this article as no datasets were generated or analyzed during the current study.

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Supporting Information

Additional supporting information can be found online in the Supporting Information section.

Supporting Appendix: Data S1