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IFR International Federation of Robotics

POSITION PAPER

The Impact of Robots

EMPLOYMENT, PRODUCTIVITY AND COMPETITIVENESS

Picture Source: Universal Robots

IFR International Federation of Robotics

CONTENTS

IN BRIEF

Intro

Robotics and automation are transforming industrial production across the world. Robotics is increasingly central to productivity, competitiveness, trade, and the organization of work.

Why are organizations automating

Several structural forces are driving the increasing need for investment in robotics. Demographic change and aging populations are reducing the available labor force in many advanced economies, creating persistent labor shortages in key sectors such as manufacturing, logistics, and healthcare.

At the same time, global competition is intensifying, requiring firms to increase productivity, improve quality, and remain cost-competitive. Robotics also enables firms to reshore production and strengthen supply chain resilience after periods of disruption, while supporting greater flexibility in industrial processes.

In parallel, relatively high wage costs in automatable occupations and the need to improve working conditions are accelerating the substitution of repetitive, hazardous, or physically demanding tasks.

Together, these factors make robotics a strategic investment for maintaining industrial capacity, sustaining economic growth, and ensuring long-term competitiveness.

Industry analysts note that automated systems are actively optimizing production workflows, reducing human error, and minimizing material waste across factory floors. Furthermore, factories are maximizing machine utilization to achieve unprecedented output levels and lower production costs. This is due to automation benefits, such as continuous 24/7 operations, eliminating traditional downtime associated with shift changes, and worker breaks.

However, the impact of robots on employment remains highly debated. Concerns about job displacement coexist with evidence of productivity gains, new job creation, and improved company and country competitiveness.

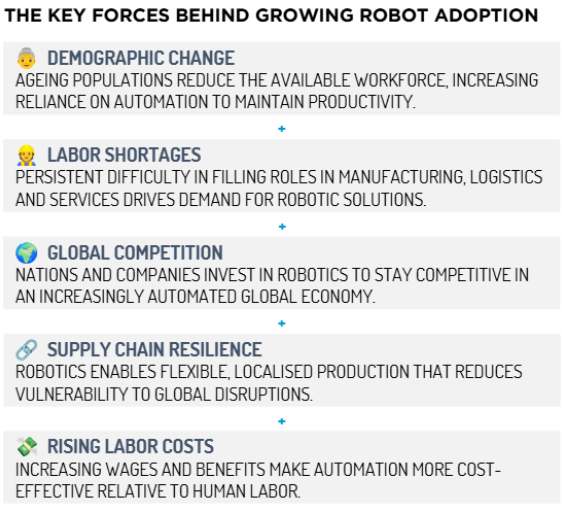

Figure 1: The Five Drivers of Robotics Adoption

The economic effects of robotics are best understood as the result of three interacting forces: **displacement**, **productivity**, and **reinstatement** effects. While some tasks are automated, robots also complement labor, raise output, and can ultimately support employment and wage growth.

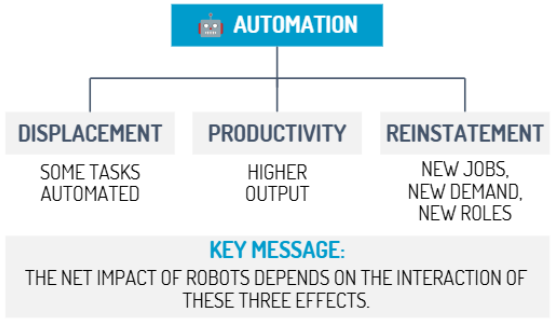

Figure 2: The economic effects of robotics.

This paper reviews the evidence on the economic and social impacts of robotics and argues that, with appropriate skills and policy frameworks, robotics can be a key driver of productivity, industrial competitiveness, better working conditions and quality employment.

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10 KEY FINDINGS ON THE IMPACT OF ROBOTS

01 AUTOMATION CREATES JOBS THROUGH PRODUCTIVITY GROWTH

02 ROBOTS SUBSTITUTE TASKS, NOT ENTIRE OCCUPATIONS

03 SKILLED LABOR IS THE KEY TO CAPTURING THE BENEFITS

04 ROBOTS STRENGTHEN COMPANY COMPETITIVENESS

05 ROBOTS HELP CLOSE LABOR GAPS

06 ROBOTIZATION ENHANCES NATIONAL COMPETITIVENESS

07 ROBOTS HAVE A POSITIVE IMPACT ON WAGES

08 AI AND ROBOTICS ARE LEADING TRANSFORMATION

09 AUTOMATION HELPS COUNTER DEMOGRAPHIC CHANGE

10 A NATIONAL ROBOTICS STRATEGY IS ESSENTIAL

AUTOMATION'S OVERALL IMPACT DEPENDS LESS ON WHETHER ROBOTS ARE ADOPTED AND MORE ON WHETHER COUNTRIES AND FIRMS PAIR ADOPTION WITH SKILLS DEVELOPMENT, WORKER TRANSITION SUPPORT, AND A COHERENT NATIONAL ROBOTICS STRATEGY.

EXECUTIVE SUMMARY & KEY FINDINGS

1 Automation creates jobs by increasing productivity

The rise of industrial robotics has led to increased labor demand and higher wages in key sectors, challenging the long-held fear that automation would result in widespread job losses. The productivity gains unlocked by robotics are stimulating broader market demand. Consequently, many firms are expanding their workforce to keep pace with increased sales, thereby creating more employment opportunities. International studies show that increased robot density accelerates labor productivity growth and accounts for roughly 10% of total GDP growth in advanced economies.[1]

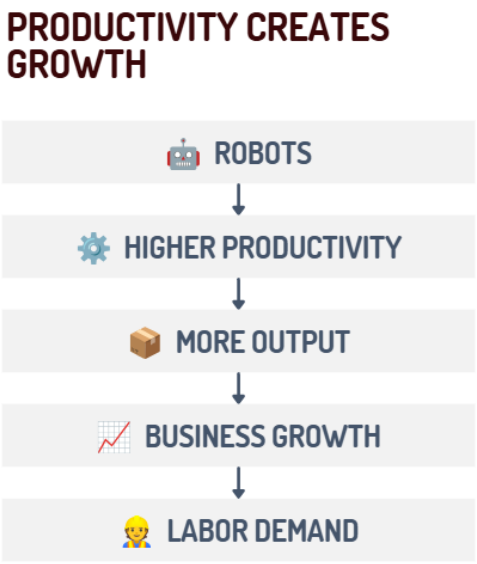

Figure 3: How robots drive business expansion and labor demand.

While both job creation and displacement are anticipated, the World Economic Forum projects a net global increase of jobs suggesting that AI, robotics and digitalization combined are expected to have a positive overall employment impact. This is in line with data recorded in the European Union. Between 1999 and 2010 automation has driven a net increase of over 10 million jobs in the EU 27.

2 Robots substitute labor but not jobs

Industrial automation is reshaping workplaces on the factory floor. Although robots are taking over specific roles within any given occupation, only a small subset of tasks can be fully automated. This shift is creating a wave of new roles focused on oversight and technical management, forcing traditional job profiles to evolve rapidly.

By taking over dirty, dull, dangerous and delicate tasks, robots are improving the **quality of work**. These devices augment human capability, enabling workers to perform heavy or dangerous tasks, such as heavy lifting or handling hazardous material, with significantly higher safety margins. This technology is also proving beneficial for inclusivity, enabling people with physical impairments to enter the labor market and helping older staff to remain productive for longer.

3 Skilled labor key to benefit from automation

The ability to capture the economic gains of automation hinges on a **realignment of worker skills**. Human experts with practical knowledge who understand the craft and production processes are indispensable. Simply deploying automated systems is insufficient, as technological progress is outpacing current education and training frameworks. To reap the benefits of the transition, a coordinated effort is required to prevent a permanent mismatch in the labor market: Companies must engage actively in appropriate retraining programs for employees, to equip them with up-to-date skills. This goes hand in hand with governments providing policy, incentives, and education systems to support the acquisition of skills.

The integration of robots is particularly fueling demand for **high-skilled workers**. As

[1] *Georg Graetz, Georg and Michael, Guy: Robots at Work. Review of Economics and Statistics, 2018, 100 (5), 753–768.*

machines take over routine manual tasks, businesses are increasingly hiring for roles focused on technical oversight, complex problem-solving, and digital integration.

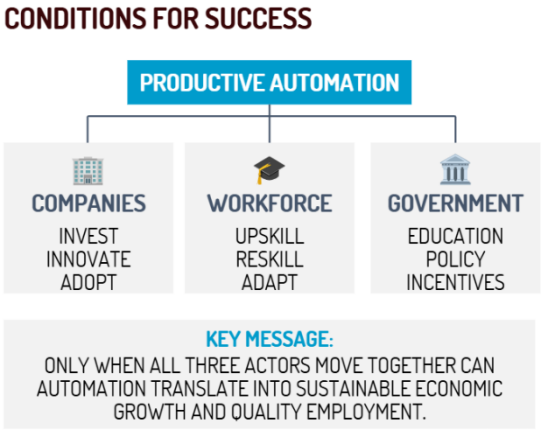

Figure 4: Collaboration is key to success.

Fears of a hollowing out of the global workforce are being countered by evidence that automation is triggering a "scale effect" that bolsters overall employment, according to senior labor economists.

While the displacement of manual tasks remains a central concern, analysts argue that the efficiency gains provided by new technology are expanding business operations at a rate that necessitates more human staff.

4 Robots enable companies to become or remain competitive

Industrial robots have become a critical tool for companies seeking to maintain or strengthen their competitiveness by improving efficiency, precision, flexibility, and production quality. This is particularly important for small and medium-sized enterprises (SMEs), which often face strong cost and productivity pressures in international competition. Empirical plant-level evidence suggests that robot adoption not only raises output and productivity in automated stages of production but also generates positive spillover effects in other parts of the plant and across other plants within the same firm, thereby enhancing overall firm performance and resilience.

[2] *Please find more details in DEEP DIVE Robots help companies in labor shortage*

5 Robots closing companies' labor gaps

Employers around the world are struggling to find people with the specialized skills required. These unfilled jobs leave existing staff covering extra shifts, with rising stress and fatigue across all sectors. A key strategy for addressing this issue is to adopt robotics and automation. In this transformation process, employers benefit from taking their human workforce on board. The close cooperation with employees in implementing robots plays a crucial role to ensure acceptance – both in industrial manufacturing settings as well as in the manifold service applications. The benefits that robots deliver, such as tackling labor shortages, taking away routine tasks or opening up new career opportunities, mean that they will be accepted as allies in the workplace. At the same time, robots are a way to make a workplace much more attractive to young people. Companies and governments are pushing skilling and upskilling programs to help workers keep up with changing skills demand and competing in an automation-driven economy.[2]

6 Positive effect of robotization on countries' competitiveness.

Increased productivity through automation is now allowing large corporations to **reshore or nearshore** production and supply chain components. By reducing reliance on low-cost labor, firms can bring operations closer to their primary markets without sacrificing margins. At the same time, they bring back jobs to the country.

Industry data shows a strong link between automation and enhanced **export performance**, providing a particular boost to developing economies. This technological integration allows emerging markets to meet international quality standards more efficiently.

The trend highlights a broader shift in global trade, where robotization is now viewed as a

primary driver of a **country's overall competitiveness**.[3]

7 Robots' positive impact on wages

Industrial robot adoption also has a positive impact on earnings. In several occupations where robot density has increased, wages have risen in line with the demand for more specialized expertise. Crucially, the data shows no negative net effect on overall wages across the economy. By stabilizing income levels and reducing the cost of goods, automation appears to be strengthening rather than eroding consumer purchasing power.

8 AI and robotics as leading transformative technologies

The combined advance of artificial intelligence (AI) and robotics is expected to further push the transformation of business operations by 2030. These core drivers of technological change will significantly contribute to productivity gains and shape future labor markets.

9 Automation blunts demographic change

Rapidly aging countries — such as the United States, China, South Korea, Japan, and Germany — are leading the world in robot adoption to combat demographic change. These five countries account for 80% of the annual total installations of industrial robots worldwide according to World Robotics 2025.

The demographic shift is one of the most significant structural risks to the world economy. As the 'baby boomer' generation retires, nations already face severe labor shortages which will have a full impact on leading industrial nations by 2030.

10 National Robotics Strategy

A unified National Robotics Strategy is essential to transform automation into macro-level prosperity. Such a framework is needed to synchronize industrial policy, workforce education, and supply chain infrastructure. National strategies for robotics in world leading industrial countries have proven to be very successful: In **Japan**, for example, the "New Robot Strategy" aims to make the country the world´s number one robot innovation hub. **China** launched their 'Made in China 2025' plan in 2015, which outlined a strategy for industrial development including a key focus on robotics. Today, the country is the largest adopter of industrial robots with an annual market share of 54% of annual installations worldwide. Most recently, China's government announced a national plan to dominate humanoid robotics by 2027.

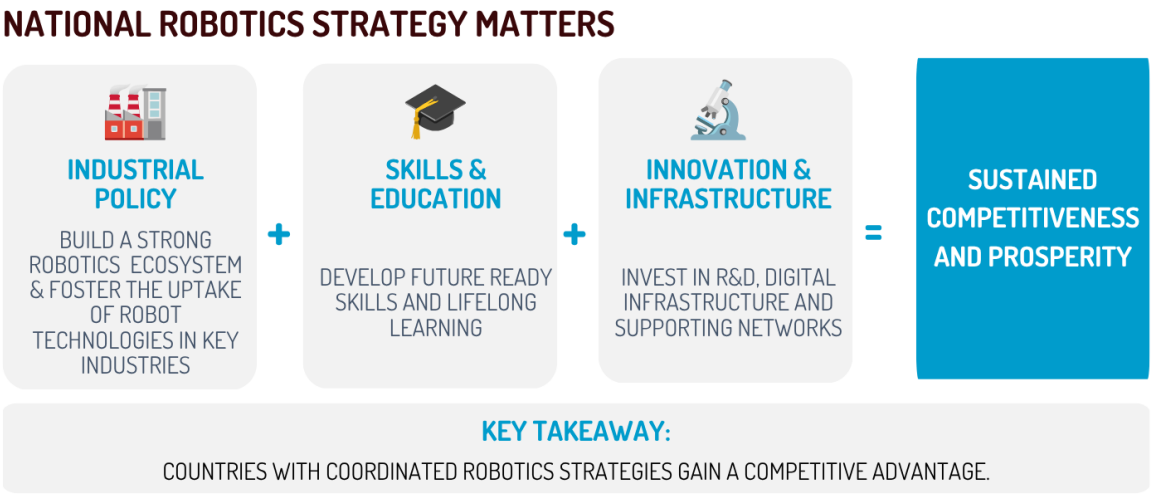

Figure 5: Countries with coordinated robotics strategies gain a competitive advantage.

[3] *Please find more details in DEEP DIVE How robots boost nations' competitiveness*

DEEP DIVE

Robots' positive impact on labor demand

Automation has driven a net increase of over 10 million jobs in the EU 27 between 1999 and 2010.[4] Jobs have grown faster in occupations using automation.[5] And a very recent study shows that robot-adopting plants increase both employment and production. The employment rises across skill groups, including production workers.[6]

The World Economic Forum's Future of Jobs Report 2025[7] projects a net global increase of 78 million jobs by 2030, suggesting that AI, robotics and digitalization combined are expected to have a positive overall employment impact.

A **triad of economic forces**[8], namely displacement, productivity and reinstatement effects, is pivotal to comprehending the impact of robots on the labor market:

The most immediate impact in the process of automation is the **displacement effect**. This occurs when robots directly take over tasks previously performed by human workers. In sectors like automotive manufacturing and logistics, demand for low-skilled workers falls and puts downward pressure on wages in automated industries.

Offsetting these losses is the **productivity effect**. As firms adopt automation, production costs typically fall, allowing companies to lower prices and expand output. This efficiency boost increases real income across the economy, driving up consumer demand. This surge in demand often leads to job growth in non-automated sectors or even within the same firms as they scale their operations.

However, regarding the relationship between robot adoption and productivity, the findings of previous research are predominantly positive. The paper "Robots at Work" by Graetz and Michaels from the London School of Economics (2018)[9] is the key reference in this regard. Based on data by The International Federation of Robotics (IFR), covering 17 industrialized countries across 14 economic sectors for the period from 1993 to 2007, they find a clear, positive relationship between robot density and growth in labor productivity. This positive relationship is driven by higher value added, not by a significant reduction in working hours. The higher value added, in turn, leads to price

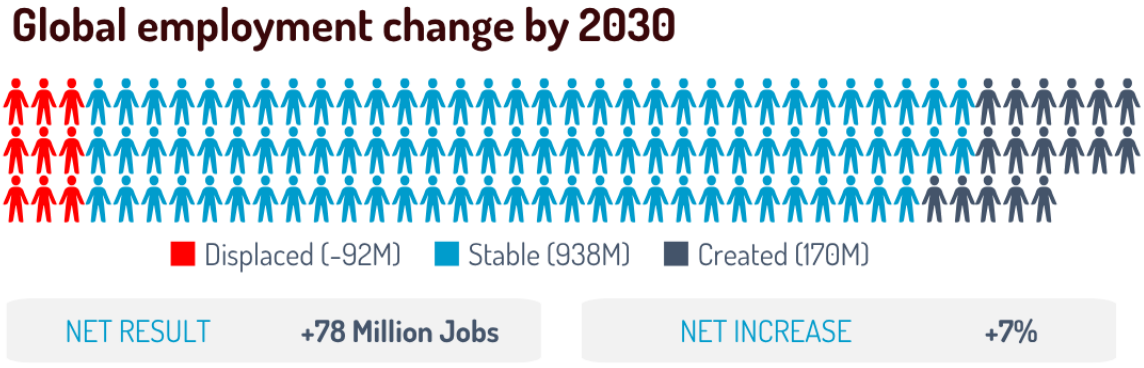

Figure 6: Global employment change. Source: World Economic Forum, Future of Jobs Survey 2024; International Labour Organization, ILOSTAT.

[4] *Zierahn, Ulrich, Terry Gregory, and Melanie Arntz. 2016. Racing With or Against the Machine? Evidence from Europe. Discussion Paper No. 16-053, ZEW Centre for European Economic Research.*

[5] *Computers Don't Kill Jobs but Do Increase Inequality, Harvard Business Review, 2016*

[6] *Adrianto, Adrianto and Ben-Ner, Avner and Urtasun, Ainhoa, Robots and Work, 2024.*

[7] *The Future of Jobs Report 2025 | World Economic Forum*

[8] *How Robots Are Changing the World (and the Economy): Anne Jurkat, Rainer Klump, Florian Schneider*

[9] *Georg Graetz, Georg and Michael, Guy: Robots at Work. Review of Economics and Statistics, 2018, 100 (5), 753–768.*

reductions in goods markets, which allow consumers to benefit from the robotization of production. Furthermore, there is a positive correlation between robotization and the development of total factor productivity (TFP).

The final pillar is the reinstatement effect, which captures how automation generates new tasks that continue to rely on human comparative advantage. Beyond the creation of roles linked directly to designing, programming, and maintaining advanced systems, automation can lead to the emergence of entirely new occupations, products, and economic activities that are more productive and, therefore, better paid, as well as the reallocation of labor within and across firms and industries. Workers consequently are often redeployed into more complex functions that require problem-solving, adaptability, interpersonal interaction, and complementary digital skills.

Robots complement and augment labor

As the integration of robotics continues to accelerate, machines are increasingly being used to complement and augment labor. Industrial robots excel particularly well at taking over **routine tasks** rather than complex work. This is due to the way their programming and hardware operate. They are built primarily for repetition, stability and calculation, whereas complex work requires adaptability, intuition and dexterity.

Examples of robotic work in factories include routine assembly line operations such as driving screws or bolts into appliances, placing microchips onto motherboards or gluing car windshields into frames. Spray painting, grinding, polishing, and vision scanning are also very common tasks that robots perform in modern factories.

However, because most jobs consist of a complex suite of responsibilities, typically, only a subset of human factory work can be fully automated. At the same time, new automation related tasks are created. This suggests a future where the workload is split: robots handle repetitive or high-precision technical duties, while humans focus on the cognitive and interpersonal elements of the role. This 'augmentation' of labor allows for increased productivity without the wholesale elimination of traditional career paths.

Education and skills development

The shift towards robotics and automation is fundamentally **reshaping the educational landscape**. Providing and retaining the right skills is crucial to reap the benefits of automation. Students are now actively adapting their fields of study based on perceived automation risks: while AI designed to augment human work encourages specialization, systems aimed at direct substitution are driving learners away from vulnerable sectors.

While technical upskilling remains a necessity in the face of widespread robotization, exposure to artificial intelligence is also fostering 'people-centered' transferable skills. Industry analysts note that the trend is moving

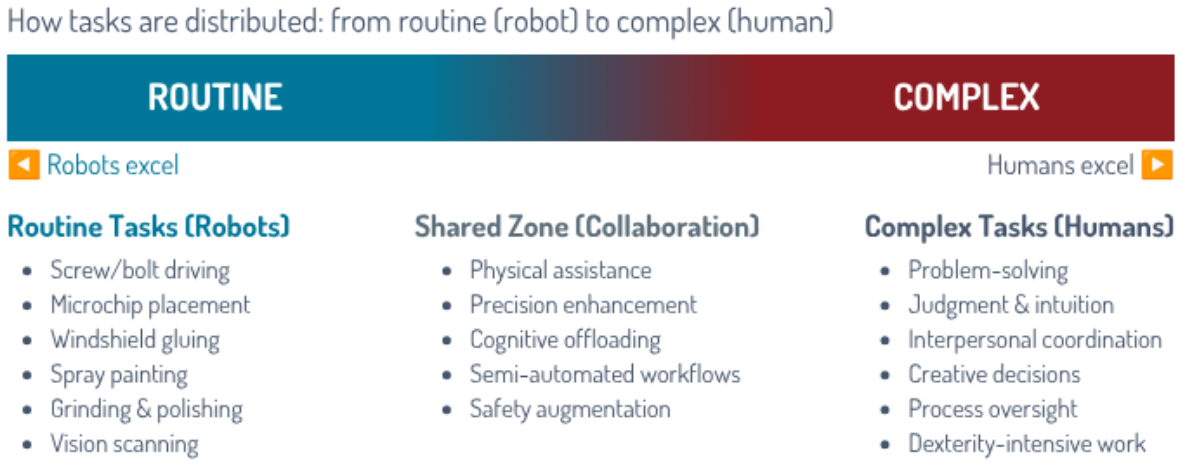

Figure 7: Robots complement and augment labor

toward a growing complementarity between human and machine capabilities.

Economists have noted that, while certain manual functions are being displaced, the partnership between humans and machines contributes to changing job profiles that require different skillsets enabling workers to delegate routine tasks and develop their abilities.

In this process, there is a positive correlation between automation and training demand: According to recent findings, plants that integrate robots see a 24% surge in new hires during the year of adoption.[10] This growth is concentrated in high-skill roles, including engineers, technicians, and managers responsible for non-routine, complex problem-solving. This transition is placing a premium on workers who can perform non-programmable tasks that machines cannot yet replicate. A study from Copenhagen Business School shows that Danish companies that adopt industrial robots do not only automate more, but they also tend to become larger, more productive and more active internationally.[11]

Competitive edge for companies

Empirical evidence on the **plant-level** suggests that robot adoption directly increases output in the specific stage of production being automated, but also generates significant positive spillover effects for the rest of the facility. These benefits allow companies to streamline operations across multiple locations simultaneously.

The findings are particularly critical for **small-to-medium sized enterprises** (SMEs), which serve as the economic backbone for both developed and developing nations. For these smaller players, the ability to scale output through targeted automation can provide a competitive edge previously reserved for larger industrial conglomerates.

By enhancing the throughput of a single robotized department, firms are finding they can optimize the performance of non-automated sections of the plant. This leads to a more cohesive and productive organizational structure. Analysts suggest that for SMEs, this multi-layered impact is a key driver in maintaining resilience amidst shifting market demands.

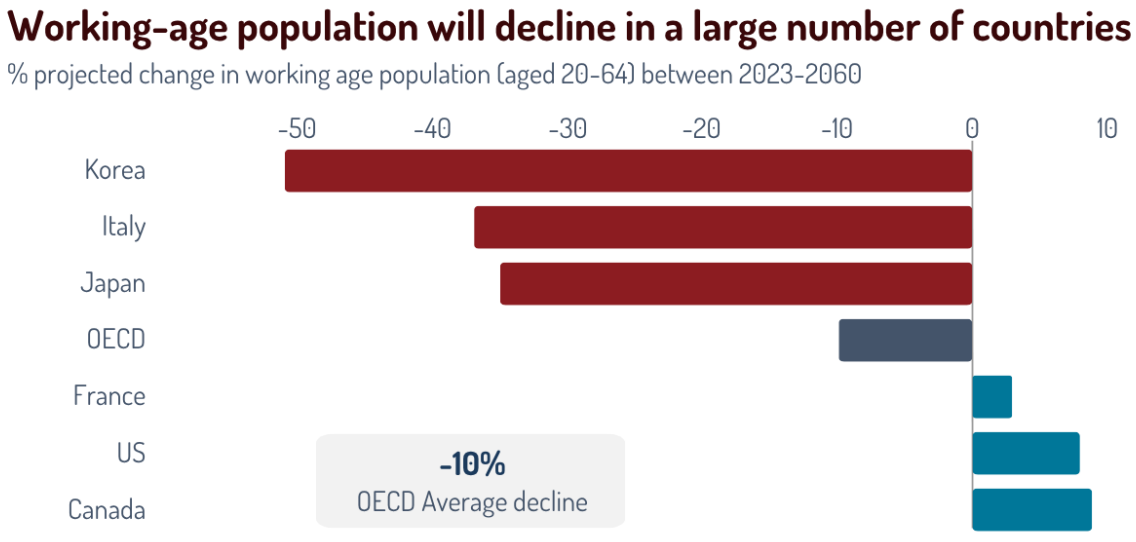

Figure 8: Most major economies face significant workforce shrinkage. Source: OECD Employment Outlook 2025

[10] *Liuchun Deng, Steffen Müller, Verena Plümpe, Jens Stegmaier. "Robots, occupations, and worker age: A production-unit analysis of employment" European Economic Review, Volume 170, 2024, 104881.*

[11] *Hu, Yan, Mann, Katja, and Pozzoli, Dario. (2026). "Where Production Meets Automation: Robots and the International Geography of Production. Study Paper No. 286. Rockwool Foundation Research Unit.*

Robots help companies in labor shortage

Companies are rapidly adopting robots to fill critical gaps caused by severe labor shortages across global supply chains. The workforce deficit stems from multiple, compounding factors. A massive wave of retirements among the baby boomer generation is depleting the current talent pool. At the same time, younger workers are not entering factory environments in the numbers required to sustain production.

This demographic squeeze is already having a significant impact on key industries in the supply chain. The acute global shortage of truck drivers highlights the scale of the challenge. Data from the International Road Transport Union shows more than 3 million driver positions currently sit vacant worldwide. Industry projections indicate these specific shortages could double by 2028. While logistics networks face similar strains across Europe, Asia, and the United States, the regional triggers and severity vary. In Japan, strict new labor regulations capping overtime are forcing domestic companies to accelerate automation. In the United States, a distinct lack of skilled logistics professionals in e-commerce warehouses is driving the need for immediate technological support.

Meanwhile, German firms are turning to automation to improve workplace ergonomics, aiming to keep an aging workforce employed in physically demanding roles. As the examples show, robotics technology is a key strategy to deal with labor shortages across industries.

Robots positively impact on wages

Although the integration of robotics widens the gap between competitive firms, it also yields clear economic advantages for certain segments of the workforce. Robots have increased wages in some occupations, particularly in organizations that invest heavily in automation. However, the widespread deployment of robots could have a negative impact on wages and employment prospects at rival companies that fail to adopt the technology.

[12] *Centre for Economics and Business Research. (2017). The impact of automation: A report for Redwood.*

Research indicates that labor market policies directly influence how rapidly corporations transition to automation. Businesses facing higher exposure to statutory minimum wage increase significantly their adoption of robots, with the trend most pronounced in manufacturing plants that rely heavily on staff performing simple manual tasks.

How robots boost nations' competitiveness

Robotization is increasingly serving as a critical pillar for **national competitiveness**. This allows major economies to maintain high employment levels while offsetting the productivity challenges of aging populations.

Nations with the **highest concentrations of industrial automation**, most notably South Korea, Germany and Japan, continue to post some of the **world's lowest unemployment rates**. The strategic push toward automation appears to mitigate the negative labor productivity effects typically associated with slowing population growth. OECD data suggests that investment in robotics contributed approximately 10% of the growth in GDP per capita from 1993 to 2016.[12] Furthermore, a one-unit increase in robotics density—defined as the number of robots per million hours worked—is associated with a 0.04% rise in labor productivity.

In Europe, the economic impact has been particularly pronounced. The adoption of robots accounted for 10% of total GDP growth across 17 European nations between 1993 and 2007. Over that 14-year span, these technological gains matched the productivity impact seen during the UK's 19th-century adoption of steam technology, but achieved the same result in just one-quarter of the time.

Robots enable reshoring or nearshoring

Automation is increasing productivity and enabling large corporations to bring production and supply chain operations back home or closer to home (re- or nearshoring). However, this technology often acts as a catalyst for

output growth rather than simply facilitating relocation.

Although robotization provides the technical capacity to bring manufacturing closer to home markets, this does not always lead to reshoring. Instead, many firms are using automation to significantly increase production volumes while retaining their existing global supply chains.

The shift towards **reshoring** is proving particularly beneficial for specialized segments of the labor market. There is evidence of a strong, positive correlation between the return of production and wages and employment. For those in these high-skilled roles, the trend is increasingly linked to higher employment rates and rising wages.

Robots support developing countries by boosting their export performance

The adoption of automation and artificial intelligence is significantly boosting **export performance**, particularly for firms in developing nations seeking to trade internationally. The most notable gains are seen when businesses use technology to drive product innovation or optimize processes. However, the impact of these technologies varies across the corporate landscape. Single-product firms are using AI to customize product design, while multi-product conglomerates are using process innovation to make complex operations more efficient.

Data shows that firms embracing automation are significantly more likely to enter **export markets** than their non-automated counterparts. Furthermore, these companies tend to outperform their competitors by increasing both the total volume and quality of their exported goods. In emerging economies, early adopters are using AI as a strategic tool to close the productivity gap with global industry leaders. By integrating these advanced systems at an early stage, these firms are positioning themselves to compete with established market leaders and accelerate their integration into global value chains.

Regional disparities of the effects of automation

Studies on the impact of robot adoption show significant regional differences in employment and wage outcomes. On a country-level this can be illustrated by comparing Japan, Germany and the United States.

In Japan and Germany, robotization is generally associated with positive or neutral employment effects. This is often explained by strong demand growth, labor shortages and complementary relationships between robots and workers. In addition, effective labor market institutions that support retraining and occupational transitions play an important role. Studies on Germany find that manufacturing job losses are often offset by new service-sector jobs and firm-led upskilling, while Japan's experience reflects strong industrial demand and limited labor supply.

By contrast, findings for the United States are more mixed: some studies identify job displacement effects from automation, while others find long-run gains in wages and employment driven by productivity growth and lower prices that stimulate demand in other sectors. Researchers also point to differences in management culture, communication practices, education and training systems. Labor market policies, and exposure to global trade are also key explanations for why the effects of robots vary across countries and regions.

AI and robotics as leading transformative technologies

AI-enabled robotics is a structural driver of economic and employment transformation. As AI tools become more common, new roles emerge for supervising, analyzing and making decisions. This is creating new jobs, including robot fleet trainers, robotics system integrators, AI-enhanced robotics technicians or machine learning specialists. To fill these new jobs, there is a growing demand for digital and cognitive skills, such as coding and data literacy, as well as critical thinking.

In future, AI in robotics will further influence how teams work, how decisions are made, and how performance is monitored. This can improve workflows but may also raise concerns about employee surveillance or reduced autonomy. Reskilling and upskilling programs are important to help workers remain competitive in an AI-driven economy. AI enhances efficiency, reduces errors, and increases output across

many industries. This can lead to economic growth but also puts pressure on businesses and workers to continuously adapt and innovate.[13] While AI is changing the way we work with robots and thus the required skillsets, there is no reason to believe that the impact on employment will be significantly different in the future.[14]

Policy recommendations

A **national robotics strategy** is essential for countries to fully capture the positive impacts on employment, productivity, and international competitiveness, in order to support national GDP overall.

A national robotics strategy should make robotics and automation a core policy priority by investing in STEM education and talent development, supporting business adoption of robotics across sectors, and increasing access to innovation funding and venture capital. It should also promote technological leadership through international benchmarking, scalable industrial deployment, and innovation-friendly regulation such as streamlined rules and regulatory sandboxes. Ultimately, the strategy should strengthen competitiveness, accelerate innovation, and prepare the workforce for an increasingly automated economy.

Governments need a clear and dedicated roadmap, with policy incentives and overhauled education systems, to ensure the workforce can acquire the necessary technical skills. Such frameworks are seen as vital to transitioning the labor market, as artificial intelligence and autonomous systems become more integrated into the global economy. Achieving these gains will require coordinated collaboration between the public and private sectors. Experience shows that state-led initiatives alone are insufficient and must be met by active participation from the corporate world. Under this model, companies are expected to engage deeply in retraining programs, equipping their existing employees with the specific skills required to work alongside new technologies.

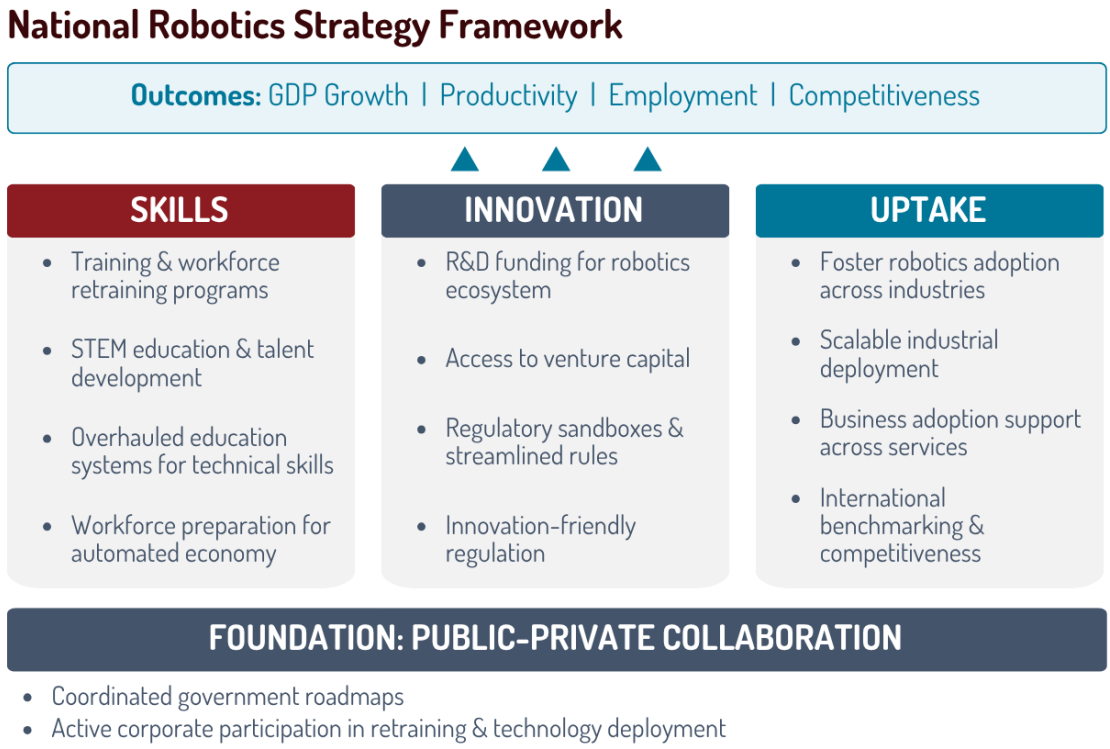

Figure 9: A national robotics strategy is essential to reap the benefits of automation.

[13] Please find more details at IFR´s position paper "AI in Robotics": trends, challenges, applications.

[14] Please find aspects about the limitations of forward-looking studies forecasting potential employment effects at the Outlook.

Outlook

Forward-looking studies forecasting potential employment effects have certain limitations impacting their predictive value. First, they often emphasize potential job destruction while neglecting offsetting job creation induced by technological change, including new occupations such as software development. Second, they equate technical feasibility with economic adoption, ignoring that many automatable tasks are not cost-effective to replace with machines. Third, they treat occupations as homogeneous units, despite automation operating at the level of tasks rather than entire jobs. Fourth, these estimates may be upward biased because they fail to account for workers already reallocating toward less automatable tasks within occupations. Finally, they often abstract from the temporal dimension of technological diffusion and the gradual nature of labor-market adjustment.

Overall, the central issue is not the net number of jobs, but the restructuring of tasks within and across occupations. Automation primarily reshapes employment composition, requiring continuous adaptation in skills, institutions, and labor supply to shifting patterns of demand across sectors.

The demographic shift will have a full impact on leading industrial nations by 2030. For the world´s top manufacturing powerhouses — the United States, China, Japan, South Korea and Germany — demographic pressures are fundamentally rewriting the future of work.

Industry leaders say that maintaining current production levels with a rapidly shrinking pool of human labor leaves these economies with little choice: Automation is fast becoming the only viable mechanism to compensate for the impending retirement wave.

At the same time, the next technological frontier is shifting how factories and offices operate. The rise of new technologies, particularly embodied artificial intelligence, such as mobile manipulators or humanoid robots, is moving machines out of isolated cages and into collaborative spaces. This integration of physical robotics with advanced AI software will unlock entirely new operational models. Instead of replacing staff, these intelligent machines are designed to work directly alongside humans. The emerging framework treats technology not as a substitute for labor, but as a critical partner required to sustain global supply chains.

APPENDIX

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