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Reimagining Employability in the Era of Industry 4.0: Skill Transformation and Policy Imperatives for India

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Abstract
Industry 4.0, the Fourth Industrial Revolution, is transforming global manufacturing through cyber-physical systems, automation, and data-driven technologies such as IoT, AI, and cloud computing. While advanced economies have embraced this paradigm, India faces significant challenges due to outdated technologies, skill deficits, and governance issues. This study explores the impact of Industry 4.0 on employability in India, identifies the evolving skill requirements, and evaluates policy measures necessary to bridge the skill gap. Using secondary data analysis and a comprehensive literature review, the findings suggest that Industry 4.0 will not eliminate jobs but will redefine them, creating opportunities for those equipped with advanced technical and interdisciplinary skills. Recommendations are provided to guide India's transition toward a digitally empowered workforce.
***Keywords:** Industry 4.0, employability, digital transformation, India, skill development, future of work.*

1. Introduction
What began as machine driven shifts now leans on smart networks linking factories to decisions faster than ever. Machines talk to machines while people watch patterns unfold across screens full of moving numbers. Instead of isolated tools doing single jobs, everything connects sensors feed information to programs that adjust operations without waiting. This shift skips slow approvals because adjustments happen mid process, shaped by live inputs rather than old Plans. Where past changes relied on physical upgrades, today's leap runs on code, signals, and constant learning. Starting off,India juggles growth with job shortages despite having plenty of workers ready to go. Because machines do more work now, people must learn new ways just to stay useful in factories and offices. Instead of old routines, tasks demand constant updates inwhat folks know how to do. Change creeps in quietly when training becomes normal, not rare.Skill fades fast unless touched by fresh practice often. Without steady learning, even willing hands risk being left behind slowly.

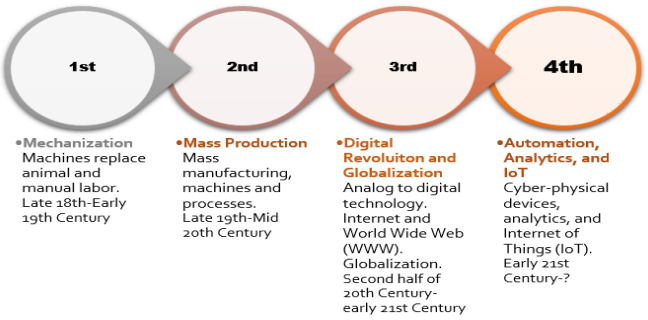

Figure 1 The four Industrial Revolutions

Source: 2025: How Will We Work? How Will Your Job Change? https://www.td.org/insights/2025-how-will-we-work-how-will-your-job-change

Figure 1 illustrates the progression of industrial revolutions, each defined by a distinct technological breakthrough: the first harnessed steam power to mechanize production, the second relied on electricity to enable mass manufacturing, the third introduced electronics and information technology to automate processes, and the fourth—Industry 4.0—

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integrates advanced digital technologies and cyber-physical systems to perform tasks once carried out by humans. Nations such as China, the United Kingdom, Sweden, Japan, Austria, the United States, and Germany have already embraced this transformation, positioning themselves at the forefront of global competitiveness. In contrast, India remains significantly behind, still operating largely within a post-electrification framework. To bridge this gap and compete effectively in the global economy, India must prioritize equipping its workforce with the skills and qualifications demanded by Industry 4.0. Strategic investment in fields such as engineering, computer science, and digital literacy is essential. By cultivating these capabilities, India can accelerate its adoption of advanced technologies, reduce unemployment, and transform its demographic advantage into a digitally empowered labour force.

2. Review of Literature

Iyer (2018), in a study with special reference to India, highlighted that one of the primary challenges in adopting Industry 4.0 lies in the country's continued reliance on outdated technologies. This dependence restricts industries from scaling up their operations, resulting in the persistence of small-sized enterprises. Furthermore, research conducted within India often remains at a nascent stage and fails to translate effectively into practical applications. In contrast, developed nations such as the USA, Germany, and China have made significant progress in implementing Industry 4.0 technologies. Therefore, India must strengthen its technological capabilities, build on its comparative advantages, and enhance workforce competencies to remain competitive. Mashelkar (2018) emphasized the transformative potential of technological upgradation in driving economic growth and generating employment opportunities for the youth. Technologies such as mobile internet, the Internet of Things (IoT), and artificial intelligence are reshaping traditional job structures, rendering many existing roles obsolete. The study cautioned that India must proactively adopt policy measures to prevent large-scale unemployment. It further suggested that industries and institutions should collaborate to create future-ready job opportunities aligned with technological advancements. Mehta and Awasthi (2019) observed that unemployment levels have already risen in recent years and are likely to worsen with the advancement of Industry 4.0 technologies, which demand higher levels of skills and capital investment. In the long run, the labor force is expected to expand; however, generating adequate employment opportunities will remain a significant challenge. Although technological adoption tends to be gradual, its impact on employment is increasingly evident. Maisiri et al. (2019) argued that the Industry 4.0 revolution necessitates a workforce equipped with specialized and advanced technological skills. As the global environment becomes increasingly digitalized and interconnected, there is a growing demand for expertise in areas such as algorithms, robotics, and automation. Consequently, a new and highly skilled workforce is required. Developing economies, in particular, face the dual challenge of rising unemployment and a shortage of Industry 4.0-ready talent. Gormus (2019) examined both the positive and negative implications of Industry 4.0. While some experts argue that automation and robotics may displace labour, leading to unemployment, others contend that these technologies will create new job opportunities. The study concluded that although demand for highly skilled and technologically proficient human resources will increase, challenges such as reduced bargaining power and inadequate legal protections for workers may also emerge. Jadhav et al. (2019) found that countries such as Japan, the UK, Sweden, Austria, and China have already embraced Industry 4.0 technologies, whereas India continues to lag behind, still operating largely within the framework of the second industrial revolution. The reasons for this lag include limited adoption of new technologies, lack of awareness, and resistance to change. Additionally, India's labour-intensive economy, characterized by the availability of low-cost labour, discourages technological adoption. The existing workforce also lacks the necessary skills required for advanced technological environments. Naz and Magda (2019) highlighted the Government of India's focus on advanced technologies, digitalization, and ICT through initiatives such as "Skill India" and "Make in India." Industry 4.0 holds significant potential to enhance productivity and technological

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advancement in sectors such as manufacturing, SMEs, and e-commerce. However, reports by the International Labour Organization (ILO, 2018) suggest that the adoption of Industry 4.0 may adversely affect job creation in the short term. Key sectors likely to experience disruptions include insurance, human resources, education, and healthcare. Furthermore, according to a World Bank report, India's workforce is expected to grow substantially, potentially reaching 70 percent, which may intensify employment challenges due to automation by 2025. Unskilled workers, in particular, are at greater risk as automation continues to reshape the job market. Srinivas (2020) suggested that this is a crucial period for India to invest in skill development in areas such as automation, ICT, IoT, and robotics. The adoption of Industry 4.0 technologies presents immense opportunities and is expected to transform work patterns significantly. Human-machine collaboration will become increasingly prominent, with advanced robotics enhancing productivity through interaction with human operators. Umachandran and Said (2020) emphasized that unemployment remains a critical challenge in the contemporary era. They advocated for an education system that aligns more closely with employment opportunities. Students must be guided to select disciplines that enhance employability, particularly in the context of Industry 4.0. The study also stressed the importance of interdisciplinary education to equip learners with diverse and relevant skill sets. Islam (2022) explored the implications of the Fourth Industrial Revolution, highlighting key elements such as data exchange, cognitive computing, IoT, automation, and cloud computing. The study questioned whether students possess the necessary skills to meet evolving industry demands. Based on data collected from 361 undergraduate and postgraduate students, the findings revealed that while students are generally aware of the skills required for the new technological landscape, there remains a gap in preparedness. The study recommended that academicians should align curricula with Industry 4.0 requirements and provide targeted training to bridge skill gaps among students lacking the necessary competencies.

3. Research problem

The research problem is the scenario of Industry 4.0 in India, what technologies and skills are required for adoption of Industry 4.0 in India, the impact of its adoption on the employment situation. To discuss this a secondary data analysis approach is adopted and data is collected through various secondary sources like books, magazines, journals, websites etc. Since, a lot of literature review is available in this regard, which points toward outdated technologies available in developing countries and not possessing the skills required by Industry 4.0 will render them an unemployment situation. The impact the Industry 4.0 has on the employability situation, especially in India, hasn't been studied much.

4. Challenges faced by India in the adoption of Industry 4.0

The writer points out that India struggles with key issues when it comes to embracing Industry 4.0

- Spending jumps when bringing in machines that work on their own. Power must run without stopping, yet steady supply feels rare across regions here. New setups need strong foundations, something still missing in many places. Learning how these smart tools operates calls for schools ready to teach them - most are not built for this task today.
- Most people still do not know much about the tools behind Industry 4.0. Outdated equipment stays in use across many factories, simply because newer options feel distant or unclear. This lag pulls down progress compared to countries already moving faster. The difference shows clearly when systems are stacked side by side.
- Not knowing enough sits at the core. Workers fail to grasp what Industry 4.0 actually offers. Because of that gap, hesitation grows inside companies. Without clear insight, people push back instead of moving forward. What seems like refusal often comes from blank spaces in learning. Firms stall not out of stubbornness but from missing pieces in their thinking.
- Faulty defenses leave digital networks open to attacks like stolen information or leaks. When protection tools lack strength, people hesitate to

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rely on modern industrial tech. Not every system handles risks well - gaps show up fast under pressure.

- What shapes progress? Short-term political goals take center stage, pushing lasting economic growth aside. When corruption creeps in, money meant for change loses its way. Leadership gaps show up most where systems fail quietly. Industrial updates stall, not from lack of ideas, but from weak oversight. Power without accountability moves slowly, dragging potential behind.
- When streets fill with protests, business slows down. Curfews shut things early. Lockdowns freeze movement across cities. Because of this, companies hesitate to spend on new tech. Uncertainty stretches timelines. Progress toward modern industry drags behind each disruption adds delay. Momentum fades without steady ground.

5. Industry 4.0 tech used in manufacturing

People working alongside machines now see fresh ways of doing tasks, thanks to Industry 4.0 reshaping factories. Old-school methods mix with smart digital tools in these updated setups. You'll find such changes grouped mainly under physical gear, programs that run them, along with how devices link up - according to reports by UNCTAD in 2021 and UNIDO two years earlier.

5.1.Hardware

Starts with gears, not dreams - robotics is an engineering field shaping how machines move and work. Machines come alive through careful planning, their actions smooth because mistakes get cut fast. Precision drives them; effort fades when these tools take over jobs once done by people. Working together with people, collaborative robots - often called cobots - are built to be reprogrammed easily. These machines boost output by teaming up instead of taking over tasks completely. A single object takes shape layer by layer, guided by a digital blueprint. Machines build forms people once carved or molded by hand. What used to take days now finishes before lunch. Design shifts happen fast - no need to wait for tooling changes. Custom pieces emerge without extra setup headaches.

5.2.Software

Massive amounts of information often slip through the cracks when using regular tools. These piles of data demand something stronger than old-school systems. Looking into them closely reveals patterns once hidden from view. Clarity comes not from size but how it gets handled. Answers appear where most wouldn't think to check first. Machines can now do it. Learning, solving problems - these tasks once belonged only to humans. Now they're built into systems that make factories smarter. Reasoning isn't just a brain thing anymore. Efficiency rises when tech mimics minds. Tasks get done differently these days. Smarter patterns emerge without constant oversight. Human-like smarts are inside circuits now. Industrial work shifts under quiet progress.

5.3.Connectivity

Out there, everyday gadgets link up - each packed with tiny sensors that grab information nonstop. These things talk to one another, passing details back and forth without waiting. From streetlights to fridges, they react instantly based on what they sense around them. As more join in, the web grows wider, smarter, always updating itself. Information flows freely between machines, shaping responses before humans even notice a change. Something moves when told - actuators make that happen by turning signals into motion. These parts push, pull, or rotate based on electronic cues. Instead of thinking, they do; a switch flips and action follow. Hidden inside machines, they bridge code and movement. Not always visible, yet essential for operation. Each time a device shifts position, one of these is likely behind it. Fresh off the line, sensors track how things change by catching light patterns or heat signals. Instead of guessing, these tools watch every shift during making stuff. They stick around quietly, spotting what needs attention without slowing down. Through tiny eyes and smart feedback, they help keep each piece just right. With the advent of Industry 4.0, the nature of work in manufacturing will undergo a fundamental transformation. Skilled labor will no longer be confined to repetitive or narrowly defined tasks; instead, workers will be required to take on more complex and dynamic responsibilities. Collaboration with robots and intelligent systems will become

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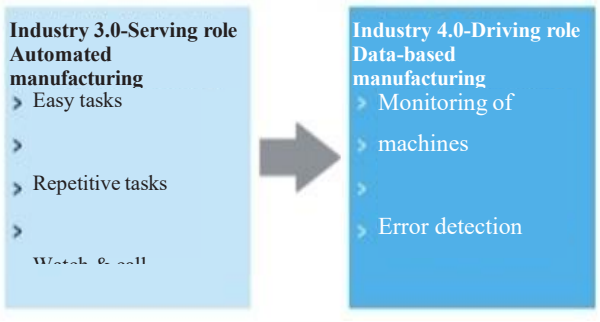
routine, with humans retaining authority over critical decision-making and oversight. Teamwork and adaptability will be central, as employees integrate their expertise with advanced technologies. Importantly, the skills demanded in Industry 4.0 do not replace those of Industry 3.0 but build upon them, requiring workers to expand their competencies to include digital literacy, problem-solving, and the ability to manage cyber-physical systems. This evolution underscores the shift from task-based labor to knowledge-driven roles, where continuous learning and innovation are essential.

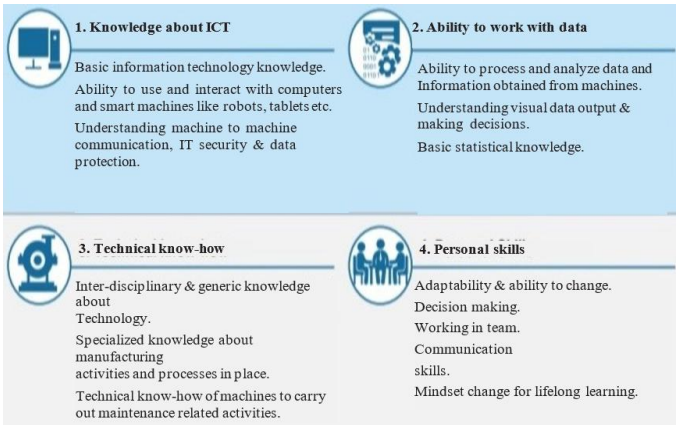


Source: Festo Didactic

Figure 2 Change in role with Industry 4.0

6. Skill gap in India

The National Policy on Skill Development and Entrepreneurship (2015) revealed a stark contrast in global training levels: only 4.7 percent of India's workforce had received formal skill training, compared to 52 percent in the United States, 80 percent in Japan, and 96 percent in South Korea. A study conducted by the National Skill Development Corporation (NSDC) between 2010 and 2014 projected an additional requirement of 10.97 crore skilled workers by 2022 across 24 key sectors, alongside the need to skill, reskill, and upskill nearly 29.82 crore workers in both farm and non-farm activities. The NSDC 2019 report further estimated that approximately 7 crore individuals aged 15–59 would enter the labour force by 2023, intensifying the demand for skill development. Data from the Periodic Labour Force Survey (2019–20) highlighted the severity of the gap: 86.1 percent of workers in the 15–59 age groups had not received any vocational training, while only 13.9 percent had acquired skills through formal or informal channels. The Wheebox India Skills Report (2022) underscored this challenge, noting that just 48.7 percent of youth were employable, with nearly 75 percent of companies reporting significant skill shortages. Although employability improved slightly in 2023 to 50.3 percent, demand for skilled labour remained concentrated in sectors such as e-commerce, IT, and pharmaceuticals. Hiring of fresh graduates was projected to rise by 20 percent, with states like Uttar Pradesh, Delhi, and Maharashtra emerging as talent hubs in automobile, internet, and engineering industries. Despite these gains, structural unemployment persists. The Centre for Monitoring Indian Economy (CMIE) report (2022) recorded an unemployment rate of 7–8 percent, reflecting a 5 percent increase over the past five years. Meanwhile, the Confederation of Indian Industry (CII) estimated a requirement of 201 million skilled workers in 2022, rising to 300 million by 2023. These figures collectively highlight India's urgent need to bridge its skill gap through comprehensive reforms in education, vocational training, and workforce participation policies to meet the demands of Industry 4.0.



Source: Roland Berger

Figure 3 Important qualifications and skills to have for Industry 4.0

The World Economic Forum's Future of Jobs Survey (2016) underscores the urgent need for a shift in workforce skills driven by rapid digitalization. Employees will increasingly be required to acquire new competencies to remain relevant in the evolving labor market. As depicted in Figure 3, these skills can be grouped into four broad categories. Greater

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emphasis will be placed on foundational knowledge of information technology, the ability to interact with smart machines, proficiency in IT security and data protection, decision-making capabilities, and statistical literacy. By contrast, relatively less focus will be directed toward adaptability, communication skills, mindset change, and interdisciplinary knowledge. This reorientation highlights the transition from traditional skill sets to digitally integrated, data-driven expertise, reflecting the demands of Industry 4.0.

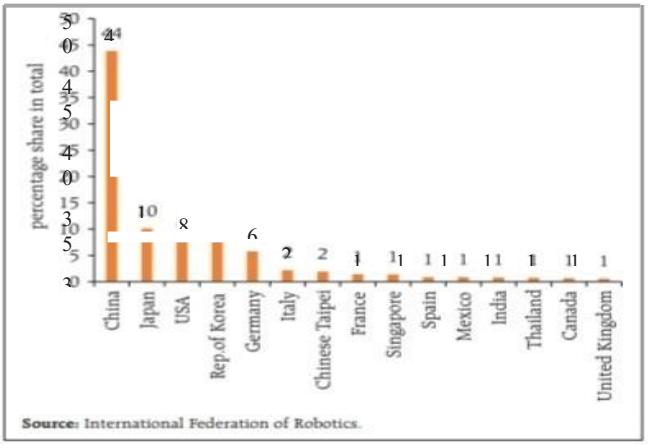
7. Impact of Industry 4.0 on other countries

According to the Confederation of Indian Industry, several nations have taken distinct approaches to adopting Industry 4.0:

- **Germany:** Germany has positioned itself as a leader in Industry 4.0 by emphasizing research, innovation, and modern manufacturing practices. Although industries face challenges such as funding requirements, skill shortages, and cybersecurity risks, the Federal Ministry actively supports small and medium enterprises (SMEs) by providing education, resources, and technical expertise to ease the transition.
- **United States**: The U.S. established the National Network for Manufacturing Innovation (NNMI), a system of regional hubs designed to accelerate advanced manufacturing. These hubs promote the adoption of cutting-edge technologies such as 3D printing, thereby fostering innovation and industrial growth.
- **Vietnam:** Vietnam's industries remain largely in the second industrial revolution stage. While technology is not entirely absent, issues of quality and scale persist. To advance, manufacturers have urged the government to introduce policy reforms that encourage modernization and adoption of Industry 4.0 practices.
- **United Kingdom:** In the UK, awareness of Industry 4.0 remains limited, with only about 8 percent of manufacturers familiar with its processes. However, a majority—nearly 59 percent—acknowledge that Industry 4.0 will have a transformative impact on the manufacturing sector, signalling the need for greater education and investment.
- **China:** China has aggressively pursued Industry 4.0 alongside its Made in China 2025 initiative, launched in March 2016. This dual strategy has significantly boosted productivity, with estimates suggesting a 25–30 percent increase in efficiency and a 60 percent reduction in production losses.

8. Result and discussion

Data from the NSSO 68th round survey reveals the stark educational profile of India's workforce: nearly 49 percent have only primary education, 27 percent are illiterate, 16 percent have completed middle school, 19 percent possess secondary education, and just 8 percent hold a graduate degree or higher. This limited educational attainment poses a significant challenge for policymakers attempting to prepare the workforce for advanced technologies. Training individuals with such low baseline qualifications to operate within Industry 4.0 systems is a formidable task. Studies conducted by organizations such as the World Bank and Oxford University further emphasize India's lag in adopting modern technologies, underscoring the urgent need for investment in digital infrastructure and skill development. Without substantial technological advancement, productivity gains will remain elusive, leaving India at risk of falling behind in the global race toward Industry 4.0.



Source: International Federation of Robotics

Figure 4 Industryrobot installations: Country-wise

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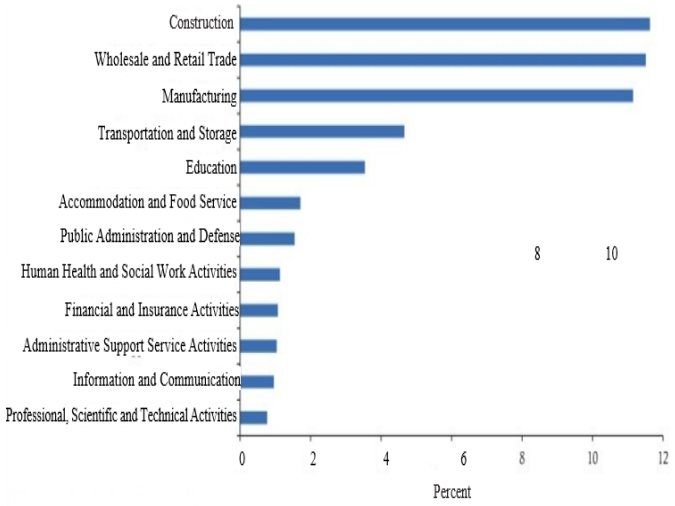
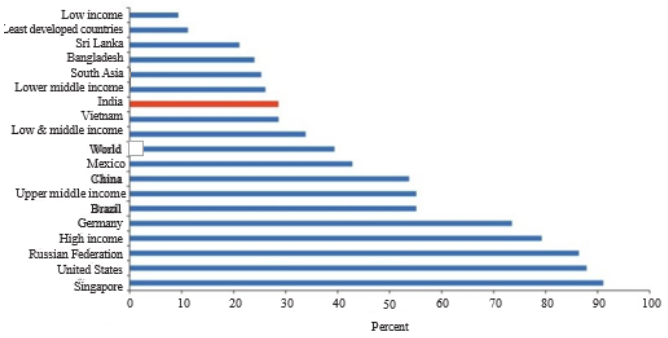
The use of industrial robots in the process of manufacturing is on the rise having five main markets reporting for 76 percent of installation of industrial robots. As shown in Figure 4, India has 0.8 percent share only, which is very small. In the manufacturing sector, the world density of robots, 2020 was 126 robots per 10,000 employees. Asia constitutes 134 units of robots per 10,000 employees. According to the International Federation of Robotics, World Robotics, 2021, the installation of robots rise considerably by 0.5 percent during 2020. China comes first in terms of the industrial robot installation. Japan is next to China. The Republic of Korea is the fourth largest in terms of installation of robots annually after the US. As per World Bank 2019, like other technologies, Industry 4.0 with its beginning gives hope for more employment opportunities. As technology brings with itself the productivity of labor in many sectors, resulting in reduced labor demand in day-to-day tasks.



Source: Periodic Lab our Force Survey

Figure 5 Percentage distribution of workers by Industry-India

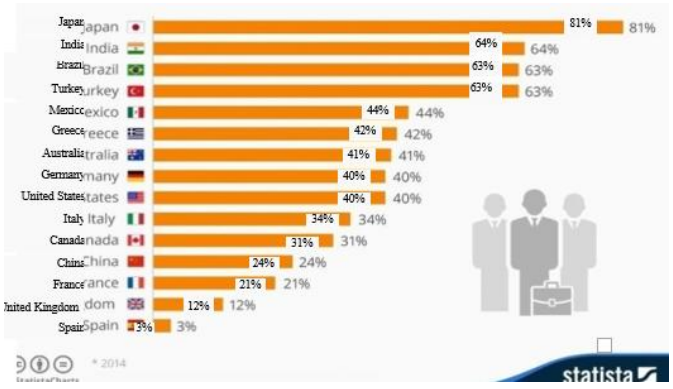
India's employment structure, as per Figure 5 above, shows more than two-thirds of the labors other than agriculture derive their livelihoods from the manufacturing sector and with the introduction of Industry 4.0; all the services will become more capital-intensive, thereby reducing the employment level.



Source: World Bank, World Development Indicators

Figure 6 Tertiary school enrollment

Figure 6 highlights the significant educational gap within India's workforce. Only 11.8 percent of labourers hold a graduate-level qualification or higher, while nearly two-thirds of the population has attained only secondary education or below, placing them in the category of low-skilled or unskilled workers. In 2019, India's tertiary enrolment ratio was not only below the global average but also lower than that of other low middle-income countries, underscoring the scale of the challenge. For Industry 4.0 to succeed, it is imperative that advanced skills be imparted across the working population. However, the limited educational qualifications prevalent in India remain a major barrier, making large-scale skill development and higher education reforms essential to prepare the workforce for the demands of digital transformation.



Source: Manpower Talent Shortage Survey via OECD

Figure 7 Countries facing the greatest skill shortages

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OECD data presented in Figure 7 highlights the widespread challenge of skill shortages across advanced and emerging economies. In Japan, approximately 81 percent of firms report difficulties in recruiting employees with the necessary expertise. Similarly, surveys reveal that nearly 45 percent of the global workforce lacks the skills demanded by employers, underscoring a significant mismatch between technological progress and human capital readiness. This issue is not confined to Japan; Mexico faces comparable concerns, while in Europe, around 40 percent of employers in 2013 acknowledged challenges in finding suitably skilled workers, particularly in the manufacturing sector. The rapid pace of digitalization and the adoption of Industry 4.0 technologies have intensified these pressures, as the skills required to operate and innovate within modern production systems evolve continuously. Addressing this gap is critical to ensuring that economies can fully leverage the benefits of Industry 4.0 without exacerbating unemployment or productivity constraints.

Conclusion

After reviewing multiple studies, it can be concluded that Industry 4.0 will not necessarily lead to widespread unemployment in India; rather, it will generate new opportunities for individuals equipped with the right skills. The challenge lies in ensuring that the number of skilled workers keeps pace with technological change. If the unskilled workforce continues to outnumber those with advanced competencies, strong political leadership, effective governance, foreign direct investment (FDI), and supportive government policies will be essential to safeguard livelihoods. Expanding access to training and education in emerging technologies is critical, as only low-skilled workers are at immediate risk of displacement. By prioritizing skill development and continuous learning, India can reduce unemployment and position its workforce to thrive in the digital economy.

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