Research notes

Automation at the Gate: Labour and Skilling Challenges in India's Manufacturing Sector Amid Rising Robotics and Industrial Automation

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Abstract: *This study examines the labour and skilling challenges confronting India's organised manufacturing sector as robotics and industrial automation accelerate under the industry 4.0 paradigm. While automation offers significant gains in productivity and global competitiveness, it simultaneously displaces large segments of semi-skilled and unskilled workers who lack the technical competencies to operate, maintain, or productively coexist with advanced automated systems. This study explores the nature and scale of this displacement, the structural gaps in India's skilling ecosystem, the role of corporate training programs and government initiatives, and the broader socioeconomic consequences for workers dependent on manufacturing employment. Drawing on secondary data, industry reports, and policy frameworks, this study argues that automation without parallel investment in workforce transition creates a deep and widening skills gap. This underscores the need for proactive, inclusive, and technology-aligned skilling reforms that enable workers to adapt rather than be rendered redundant by machines entering their factories.*

Keywords: Automation, Industrial Robotics, Industry 4.0, Labour Displacement, Manufacturing Workforce, Skilling

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INTRODUCTION

Manufacturing has long been the backbone of stable, large-scale employment in developing and developed economies. In India, the sector directly employs over 60 million workers and contributes approximately 17% to the national GDP (ILO, 2022), serving as a critical pathway for millions of semi-skilled and rural workers. Historically, entry barriers were modest; basic physical capability and willingness to train were often sufficient to secure a factory livelihood.

However, this foundational employment model is currently experiencing an unprecedented structural shift. The arrival of robotics, artificial intelligence, and interconnected smart systems collectively described as Industry 4.0 is rapidly transforming what it means to work on a factory floor. Assembly lines that once required dozens of hands are being optimised to run with a fraction of the previous workforce, guided by algorithms and corrected by robotic arms with sub-millimetre precision.

For India, this transformation arrives at a particularly challenging moment in its history. Approximately 12 million people enter the job market every year, and manufacturing has been promoted as a key absorber of this demographic dividend through initiatives such as Make in India. However, automation threatens to reduce manufacturing's capacity to generate employment, even as productive output grows. This paradox rising output and a shrinking headcount is at the heart of the challenge examined in this study.

REVIEW OF LITERATURE

Research on the labour market effects of automation has grown substantially in the wake of the industry 4.0 discourse. Frey and Osborne (2017) pioneered the task-based approach to estimating automation risk, finding that approximately 47% of US jobs face high computerisation risk. Subsequent adaptations of this framework to Indian labour data suggest that 35–40% of Indian manufacturing roles are at a high automation risk within two decades (WEF, 2020).

The International Federation of Robotics (IFR, 2023) reported that global robot installations grew by over 30% between 2019 and 2023, with Asia accounting for the dominant share. India's robot density currently approximately five robots per 10,000 manufacturing workers compared to a global average of 141 is low but accelerating as robot costs decline and export competitiveness pressures intensify.

On the skilling side, NITI Aayog (2023) reports that only 2.3% of India's workforce has received formal vocational training, compared to over 60% in Germany and South Korea. The McKinsey Global Institute (2019) identifies technical skills, higher-order cognitive skills, and adaptive competencies as the three categories in growing demand in automated manufacturing environments; yet, these are precisely where India's semi-skilled workforce has the most significant gaps. Fairwork India (2023) and ILO (2022) have documented the particular vulnerability of informal and semi-skilled workers to displacement without formal transition support. The literature collectively underscores a structural mismatch: automation adoption is accelerating, but the skilling ecosystem has not evolved at a commensurate pace.

METHODOLOGY

This study adopts a qualitative, secondary data-based research design. The primary sources consulted include reports from the International Labour Organization, International Federation of Robotics, NITI Aayog, National Skill Development Corporation (NSDC), World Economic Forum, McKinsey Global Institute, and Fairwork India. Industry-specific data were drawn from the Automotive Component Manufacturers Association (ACMA), India Brand Equity Foundation (IBEF), and the Ministry of Skill Development and Entrepreneurship.

A thematic analysis framework was applied to synthesise the findings across three core dimensions: (1) the nature and scale of automation-driven labour displacement in Indian manufacturing, (2) structural gaps in India's skilling infrastructure, and (3) the adequacy of existing policy and corporate responses. Where possible, the findings were triangulated across multiple independent sources. Comparative global analysis draws on OECD and IFR Reporting country-level data to identify transferable lessons for the Indian context.

RESULTS

Automation Landscape

Automation penetration varies significantly across industries; however, the trajectory is consistently upward. Large manufacturers in the automotive, electronics, and pharmaceutical sectors have aggressively automated, often matching global benchmarks. Maruti Suzuki, Tata Motors, and Bosch India have invested in robotic welding, automated painting, and cobot-enabled assembly lines. The falling cost of automation has been a key accelerator; industrial robot prices have declined by approximately 50% over the past decade, making collaborative robots accessible even to mid-sized manufacturers (IFR, 2023). Government schemes, such as the Production Linked Incentive (PLI), implicitly reward firms that achieve global productivity benchmarks, increasingly attained through automation.

Table 1: Automation Risk Across Key Indian Manufacturing Industries

Industry	Risk Level	Roles Most at Risk	Adoption
Automotive	High	Welding, Assembly, Painting	Advanced
Electronics	High	PCB Assembly, Testing	Advanced
Textiles	Moderate-High	Stitching, Cutting, Sorting	Growing
Pharma	Moderate	Packaging, Quality Check	Moderate
Steel & Metals	High	Material Handling, Inspection	Advanced

Nature of Labour Displacement

Displacement risk is deeply stratified by skill level, age, sex, and task type. Workers in routine, repetitive, and physically defined roles face the greatest risk — the same workers who have historically benefited most from manufacturing employment. A textile worker with 15 years of manual stitching experience gains no transferable advantage when automated sewing machines are installed. A visual quality inspector is replaced by machine vision systems capable of detecting defects at speeds that no human eye can match.

Older workers face steep learning curves for developing digital and mechatronic skills. Women in manufacturing, concentrated in garments and food processing, face compounded vulnerability: these sectors are among the most automation-susceptible, and women's participation in formal skilling programs remains lower due to mobility constraints and social norms. Geographically, manufacturing clusters — the automotive hubs around Pune and Chennai and textile centres in Surat and Tirupur — face cascading displacement when automation hits anchor firms.

Skills Gap Analysis

Modern factories require workers who can program and troubleshoot CNC machines and PLCs, interpret IoT sensor data, perform robotics maintenance, and adapt to rapidly evolving production systems. India's ITIs and NSDC-affiliated centres collectively train millions annually; however, only 2.3% of the total workforce receives formal vocational training (NITI Aayog, 2023). Critically, the curriculum lags technology: a mechanical fitter course based on manual tools provides little preparation for a factory floor deploying CNC systems and cobots. Quality infrastructure is concentrated in urban centres, while rural and semi-urban training centres lack equipment, instructors and industry linkages. Large manufacturers, such as Bosch and Tata Motors, maintain sophisticated in-house academies, but SMEs, which employ the majority of India's manufacturing workers, rarely have the resources for structured workforce development.

DISCUSSION

The findings reveal a structural paradox at the heart of India's manufacturing employment landscape. Automation adoption is accelerating, driven by global competitiveness pressures, PLI incentives, and falling robot costs, while the skilling infrastructure meant to support displaced workers remains chronically underpowered in both scale and relevance. This has created a widening gap between the competency demands of modern factories and the actual capabilities of the workforce seeking employment.

Global comparisons offer instructive contrast. Germany's dual education system, which mandates industry participation in curriculum design and combines classroom theory with hands-on factory apprenticeships, produces workers who are genuinely prepared for automated environments. Germany has treated automation as an opportunity for workforce upgrading, backed by strong social protection for workers during the transition. Japan's jidoka philosophy — designing automation to augment rather than replace human workers — and its investment in retraining older workers demonstrate that experience retains value even in highly automated settings. By contrast, China's experience illustrates the risks of speed without support: rapid robot deployment generated efficiency gains but also significant regional displacement in lower-skill manufacturing zones.

India cannot rely on a high-cost labour market to pace organic adoption, nor does it have China's fiscal capacity to absorb large-scale displacement through alternative economic expansion. Therefore, a deliberate, funded, and inclusive workforce transition strategy is essential. Promising interventions exist within the current framework: the National Apprenticeship Promotion Scheme (NAPS) provides a direct training-employment link and could be significantly expanded for SMEs; PMKVY's Recognition of Prior Learning modules offer a pathway to formalise existing skills; and a shared skilling infrastructure model — automation training centres accessible to clusters of SME manufacturers — could address resource constraints that prevent individual firms from investing in workforce development.

CONCLUSION

The rise of robotics and industrial automation in India's manufacturing sector presents a genuinely complex employment challenge for the country. Automation is becoming increasingly prevalent as it makes economic sense for manufacturers competing in global markets, and it will continue regardless of resistance. The central question is whether India can manage this transition in a manner that protects the employment prospects of a large, young, and partially formal workforce or whether the demographic dividend manufacturing was meant to absorb becomes a demographic liability.

The evidence suggests that India's current skilling ecosystem, while large in institutional terms, is inadequately equipped for the pace and scale of workforce transition that advanced automation demands. Curriculum lag, unequal access, insufficient social protection for displaced workers, and a persistent training-employment mismatch collectively limit the effectiveness of existing programs. Bridging this gap requires smarter, faster, and more inclusive training aligned with real employer needs, manufacturers taking active responsibility for workforce transition, and policy frameworks that incentivise reskilling alongside productivity investment. The machines are at the gate; what matters now is how effectively India prepares the people already inside.

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